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ABSTRACT

Designed to assist vocational education program planners as well as researchers in making manpower projections, this report attempts to sort out and classify forecasts and their underlying models. In reviewing this subject, major sections of the document were devoted to: (1) The Forecasting Process, (2) Unspecified Techniques, (3) Specified Technological Models, (4) Specified Economic Models, (5) Specified Predictive Models, and (6) Data Availability and Quality. No one model clearly boasts more advantages than any other, and the potential user should weigh the costs and benefits of a particular choice of model. However, the author stated a preference for the Occupational Training Information System (OTIS) approach which, for forecasting at the state level, has definite advantages as a total systems approach. This preference was based on the belief that the OTIS model incorporates components which should make it possible to evaluate the system's total performance and its performance in solving specific problems, particularly those of the disadvantaged worker. (Author/JS)

Information

Series No. 54

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review and synthesis
of research on

MANPOWER FORECASTING FOR VOCATIONAL-TECHNICAL EDUCATION

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REVIEW AND SYNTHESIS OF RESEARCH ON MANPOWER FORECASTING FOR VOCATIONAL-TECHNICAL EDUCATION

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PREFACE

Prior to 1900, reliable manpower forecasting would have been impossible. Today projecting manpower needs into the future is recognized as providing vital information to vocational/technical specialists.

This paper, *Manpower Forecasting for Vocational-Technical Education,* is designed to assist vocational education program planners as well as researchers in the field. It can serve as an overview of manpower forecasting to guide vocational educational planners and policy developers at local, area and state levels.

The bibliography is extensive in that it incorporates a wide range of views relevant to manpower research. Where ERIC document numbers and ERIC Document Reproduction Service (EDRS) prices are cited, the documents are available in microfiche and hard copy form.

The profession is indebted to David E. Kidder for his scholarship in the preparation of this research report. Recognition is also due Niles M. Hansen, University of Texas, Austin; J. Robert Warmbrod, The Ohio State University; and Robert C. Young, The Center, for their critical review of the manuscript prior to final revision and publication. J. David McCracken, information specialist at The Center, coordinated the publication's development.

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and Technical Education
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Technical Education

INTRODUCTION

Manpower forecasts for general planning and for specific vocational education needs have multiplied in the last 10 years. To date, vocational educators have lacked criteria which might inform choices among alternative techniques. This paper represents an attempt to sort out and classify forecasts and their underlying models, so that researchers and administrators might approach the study and use of such projection techniques efficienty.

The author is indebted to the staff of the Bluford Library and the Center for Manpower Research and Training Library (North Carolina Agricultural and Technical State University), the Industrial Relations Library (Massachusetts Institute of Technology), and the Library of the School of Education, Harvard University. J. David McCracken and the staff at The Center for Vocational and Technical Education, The Ohio State University, supplied valuable computer summaries of bibliographical sources in the ERIC system, and microfiche reproductions of sources that were hard to find. Dianne Genovese skillfully typed the final draft. The author also wishes to thank his wife, who contributed critical and editorial assistance.

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THE FORECASTING PROCESS

Vocational education officials have come to assume, in recent years, that manpower forecasting constitutes a natural part of their function. They are encouraged in this feeling by panels of experts and by the spirit of the laws, notably the Vocational Education Act of 1963 (as amended in 1968). Drafters and later interpreters of the Act assumed as a matter of course that planning, with the improved use of labor market forecasting, could better the performance of the vocational education industry. See Ruskin (1971), Warfield (1969), Rumpf (1969) and Evans *et al.* (1969). Somers (1968) observes, however, that vocational education reacts only sluggishly to industrial change, and a good part of this slow reaction can be attributed to bad data. Suppliers of forecasting models have not been idle, and a mass of predicting tools of varying degrees of sophistication has emerged during the 1960's. It is natural, then, to inquire which of the techniques, if any, offer special promise for vocational planners who want to know something about the future. This paper, which surveys a number of important techniques of manpower forecasting, will attempt to measure the value of these techniques against the requirements of forecasting models in general and vocational education forecasts in particular. We shall also consider problems which face all manpower forecasting in defining magnitudes to be forecast, collecting relevant data and building usable forecast tools.

Why do vocational education planners try to forecast? Several questions give rise to forecast needs:

1. How many students should be admitted to each specialty? On the investment side, in what curricular areas should physical and staff capacity expansion be undertaken? The Division of Education and Science in Great Britain makes forecasts of teacher and pupil supply, partly to answer the capacity question. The success of this venture has been questioned, as in Ahamad and Armitage (1970).

2. What will be the impact on vocational education programs resulting from changed patterns of participation by previously excluded groups such as blacks, Puerto Ricans, American Indians, and women? The spirit of recent manpower legislation implies that government agencies directly concerned with training and developing human resources should commit themselves to positive action in the field of minority employment. (A. Kidder, 1971.)

3. What is the appropriate design for a given curriculum? Ruskin (1971) shows, by inference, how little occupational forecasting and follow-up enters into the curriculum plans of vocational educators. Will industry's production techniques change in ways that render today's curriculum "mix" obsolete in five years?

4. What are the employers' alternative sources of supply in an occupation for which vocational education is being provided? Are these patterns subject to change over time, responding to different market and institutional forces?

5. A related question involves internal requirements of the vocational education system. From what sources will teachers and administrators come and how will this supply change with changes in labor market conditions? Gibbs (1969) treats this question in a fairly sketchy study of Wisconsin vocational education teachers. Many interesting questions, such as why teachers enter and leave the profession, receive no treatment. See also Stevenson (1966).

Any forecasting model worth using internalizes as many potential influences on employment as possible, subject to the practical constraints of time, money and knowledge. Ideally, since employment depends on individual decisions to supply labor (determined by tastes and the value of alternative uses of one's time) and industry requirements (determined by available technologies, resource costs and product market conditions), one could feel more comfortable about forecasts covering an area which roughly defined a homogeneous labor and product market. In practice, area planners can rarely control for product market conditions, since intermediate and final goods in most industries pass in and out of local areas, often in response to forces far beyond the planning area.

An ideal forecasting model, from the vocational education planners' point of view, should incorporate the following:

1. Demand and supply forecasts. Forecasts of employers' requirements should be complemented by estimates of available supply within a certain geographic distribution of employment, including individuals within the vocational education system. Breakdowns on the supply side by age, sex, race and possibly aptitude will be required to evaluate vocational education performance in meeting needs of disadvantaged groups. Supplemental data on wage levels and trends, based on employer surveys, will be needed to bolster employer forecasts of scarcity in different occupations. These data strengthen supply forecasts as well, by suggesting which occupations are (or are becoming) relatively attractive from a pecuniary point of view.

2. Classification detail sufficient to match curriculum content with skill requirements of a given job or job cluster. This requirement assumes such a match is in fact possible or meaningful, a point which receives more treatment below.

3. Technology predictions, detailed enough to allow expert assessment of required qualitative and quantitative changes in curriculum generated by productivity changes.

The ideal manpower forecasting process in general may be viewed in a systems framework, as in Figure 1. Three subsystems, the labor market, the forecasting process and the sociopolitical process constitute interacting parts of this larger system. The simple notion that labor market data furnish inputs to the forecasting process without receiving explicit feedback from other subsystems may be reasonable in the short run. It is probable, however, that over time manpower forecasts, correct or not, have independent power to influence how actors in the labor market system behave. In the extreme, forecasters may generate self-fulfilling prophesies. Events in the sociopolitical realm, such as budget cutting, may affect the quantity and quality of data entering a forecast. And the accuracy of a projection may feed back upon the sociopolitical system, influencing succeeding years' enthusiasm for the exercise of manpower forecasting.

A competent forecaster should bear in mind the complex interrelationships of these processes. In addition, his forecasting model should measure up to the following requirements:

1. The technique should be replicable at different times and in different places. This requirement concerns cost as well as technical complexity of the model.

2. All assumptions of the model should be reasonable, and should be explicitly and clearly stated.

3. The structure of the model should be thoroughly explained, in language understandable to potential users of the model.

4. Forecasted estimate errors should be included.

5. Forecasted subtotals should be internally consistent, and should be cross-checked to prove consistency.

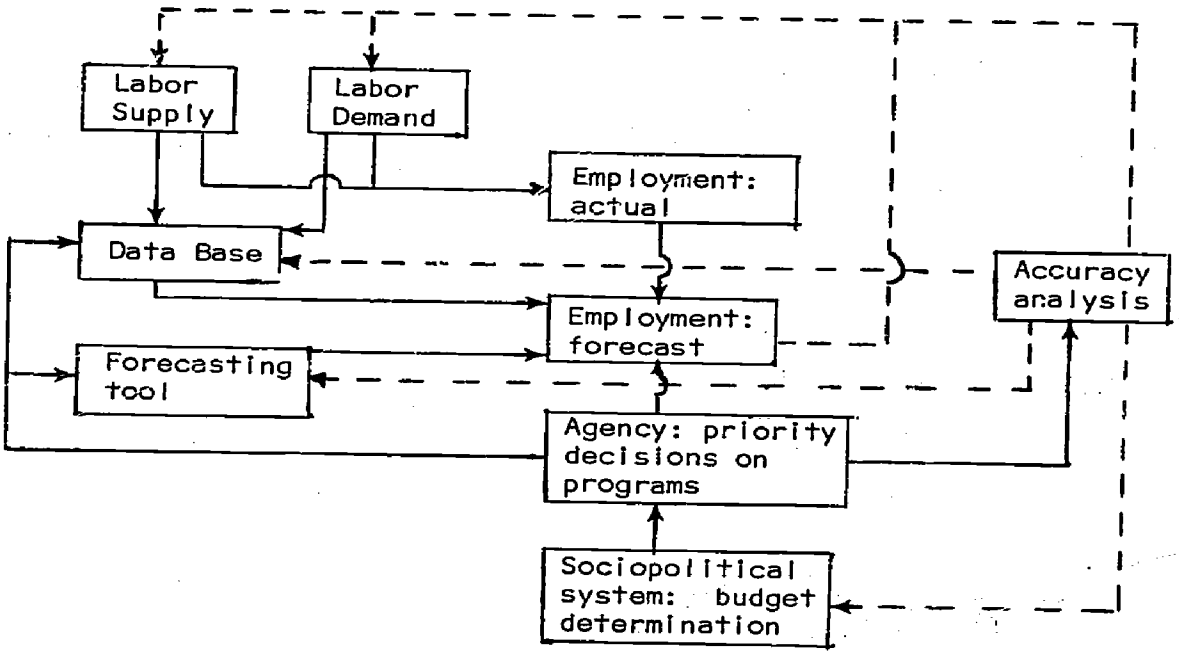
6. Accuracy analysis should be an integral part of the forecasting process.

Swerdloff (1966) discusses a number of other problems we shall treat, including normative versus descriptive forecasts, projections of optimum versus current amounts and the like. See also recommendations of the Working Group on Manpower Projections, U.S. Department of Labor (1967).

In what follows, we shall analyze strengths and weaknesses of various forecasting techniques as they meet the criteria of 1) general requirements of good manpower forecasting technique, 2) requirements for planning vocational education, and 3) sensitivity to the interactions of labor market processes and the forecasting process itself.

Figure 1

An Ideal Model Forecasting System



Note: Solid lines trace primary activities and influences: dashed lines trace feedback

Models and Data

Generally it is wise to separate the model used in forecasting from the model's data inputs when evaluating the effectiveness of a given technique. A rigorous approach, standard among many social scientists, specifies that the researcher first construct his model (assumptions, definitions and hypothesized relationships) and then seek out an appropriate data base to test the model. The model's structure and component variables supply enough information concerning how much and what kinds of data are needed.

Options available to policy-makers often force less rigor, however. Statistics collected by governmental agencies, as a matter of course, suggest indicators which busy planners can use to chart evolving trends in labor markets. Data can determine the model applied instead of the reverse. It is quite difficult to evaluate such a "model" without simultaneously evaluating the data inputs, since the two are tied. On the other hand, a forecaster may have constructed an *a priori* model, based on well understood principles of economics, only to modify it subsequently as data limitations become apparent. In this case, the analyst can separate structural and data questions, recognizing that a model may be testable from a variety of data bases and at different levels of aggregation.

Organization of Study

We shall consider models classified in the following manner:

1. Unspecified: usually data-generated techniques, the assumptions and structure of which are not spelled out.

2. Specified technological models: Distinguishing between technological and economic models, we follow the terminology introduced by Bowles (1969). Models in this category reflect technological assumptions about production, which generate fixed (or changing in accordance with exogenously specified trends) employer demands for and worker supplies of labor. In economic terms, we talk of fixed production coefficients, invariant to changes in relative resource costs. Assumptions may or may not be spelled out, and technological forecasts may vary in complexity from simple extrapolations to complex input-output projections.

3. Specified economic models: Systems which are offered to explain employer and worker behavior under the economic assumptions of maximizing net benefits from some activity comprise this category. Measured parameters reflect the best approximation to optimal solutions that the researcher can obtain. Linear programming and cost/benefit approaches are common types of economic models. It should be noted that forecasts based on static optimization may or may not exhibit the economic sophistication of the original model.

4. Specified predictive models: Least squares regression estimates of supply-demand forces in a labor market fall in this category. Forecasts should, in a tightly structured framework of this kind, be replaced by predictions or simulations based on a relatively thorough understanding of the systems' behavioral characteristics. Optimizing, in the sense used above, is not always an

explicit feature of predictive models, though the assumption of classical economics, that employers maximize profits, for example, is part of the implicit behavioral structure.

We have chosen to classify models by their structural characteristics. In taking this approach, we parallel the studies of Mehmet (1965), Srivastava (1964), Cummings (1970), and the Institute of Applied Manpower Research (1963). Hansen's (1965) five-way classification of models constructed to yield "requirements," "availables," "outcomes," "outcomes with responses" and "actuals" concentrates on two issues: 1) Does the forecast encompass job openings, available manpower or some net of the two and 2) is the forecast purely *ex ante,* descriptive and without attempt to reconcile predicted and actual magnitudes, or is it *ex post* as well as *ex ante,* with reconciliation and implied evaluation of the results?

Morton (1968) classifies forecasts as explicit, derived from general population forecasts or derived from economic forecasts designed to produce other outputs, or "techni-cultural conjectures." The bulk of his technical discussion concerns specific choice of functions to be projected or fitted (low and high order polynomials, orthogonal polynomials, least squares, log trends, ogives, the logistic curve and so forth). We shall not discuss critically these familiar demographic tools, but refer the reader to Morton's excellent analysis. See also, *Study of Methods for Forecasting Employment* (Sturmthall, 1967) *and Trained Manpower for Tomorrow's Agriculture* (OECD, *1966).*

Since vocational education planners typically operate at a subnational level, we shall emphasize regional (local, "small area," metropolitan) forecasting. National forecasting exercises have use as reference points for local forecasts, and techniques, of course, may be interchangeable. Institutional planning (a firm's manpower projections of its own requirements, for example) also influences the quality of a regional forecast, to the extent that it generates usable data inputs. Finally, educational planning, in which models of the educational system are built to study teacher allocation and recruitment, optimal expenditure on education and the like can improve the allocation of resources within the sector and between education and other sectors. Ideally, a good educational plan should complement a good manpower forecast. We refer the reader to certain select works in educational planning, which we shall not treat as such in this paper. See Bowles(1969), Davis (1966), Alper *et al.* (1967), OECD *Mathematical Models . . .* (1967).

The analysis of selected models will be followed by a discussion of data sources for manpower forecasting and an evaluation of their validity and usefulness. Finally, we shall conclude with a summary and tentative recommendations.

A Note on Accuracy Analysis

Strictly speaking, it is impossible, as pointed out elsewhere, to subject models discussed below to comparative accuracy analysis. Valid tests of this type require replication, at comparable time periods and for the same forecast region, of a projection based on different techniques. Such a test has never been

made on sophisticated models, though Norton (1967) constructed artificial tests of naive models on metropolitan data.

Accuracy analysis on one-time model projections has been attempted and will be discussed below. A serious problem in interpreting the results, however, arises from the presence of two types of error:

a. Forecast error (e_f)
b. Measurement error (e_m)

The former arises from incorrect perception of the future, perhaps based on a faulty model. The latter arises from improper measurement of the variable in question; for example, money wages may be a poor measure of workers' "marginal product."

Thiel (1961) points out that the variance of $e_f - e_m$ will exceed e_m only if the errors are not intercorrelated. In this event the accuracy analysis will suffer little disturbance from measurement error.

In manpower forecasting, however, it is common to estimate or measure a magnitude (such as labor force) using L x P, where L = participation rate and P = population. If L x P is then used to project the labor force, the former errors of measurement will quite likely be correlated with forecast errors and make accuracy analysis a risky business indeed.

Standard sources on accuracy analysis include Thiel (1961, 1966), and Meyer and Glauber (1964). Norton (1965, 1967) and Zitter and Shyrock (1964) illustrate the application of various measures of accuracy to manpower forecast data. Accuracy analysis in studies we shall discuss is confined to a simple relative error measure:

$$\frac{P - A}{A}$$

Where:

P = predicted value
A = actual value

"UNSPECIFIED" TECHNIQUES

Area Skill Surveys

Forecasting based on fairly unstructured models occurs every day at all levels of government. Career economists in the Bureau of Labor Statistics or the Office of Business Economics in the Department of Commerce, for example, have frequently internalized information about past trends in gross national product, employment, labor force participation and the like which they can turn into informed guesses about future trends. For every agency econometric model, built with care and attention to economic logic, tested for consistency and accuracy of fit, there are 10 staff members whose "feel" for data and trends permits them to outperform the model in forecasting future events.

In the manpower area, systematic use of unstructured models occurs in the Area Skill Surveys forecasts of the state employment security agencies and, more recently, in the application of an "unfilled openings—industry-occupational matrix" model, developed by Norman Medvin (1967, 1969) of the United States Training and Employment Service, (formerly the Bureau of Employment Security). We shall discuss the basic skill survey technique and the Medvin variant separately. An example of an unstructured data-gathering system may be found in Kraft and Prado (1971). Sacks *et al.* (1969) describe a St. Louis vocational education and occupation project, with a supply-evaluation component, which seems to have as its main goal total involvement of community leaders.

Area Skill Surveys are patterned on a model developed by the Bureau of Employment Security (BES) in 1965 (see also Burt, 1967) and are designed to secure information on the state of a local labor market at a point in time. Since state procedures may vary from the BES standard, we shall discuss one illustration, a survey of the Ventura County, California area reported by Dubinsky and Mayall in the American Statistical Association Proceedings for 1966.

Critical points in the process include sampling techniques, questionnaire design, administration and follow-up and, of course, interpretation.

The Ventura Project was based on a universe of firms which excluded only agriculture. Researchers grouped firms into a two way cross-classification to permit stratified sampling:

1. Occupationally homogeneous "strata" -- judgment decisions on appropriate groupings of industries from the Department of Commerce Standard Industrial Classification (SIC) four-digit categories were made. Results showed 32 strata.

2. Firm size -- after standardizing for an adjusted SIC definition of occupational homogeneity, researchers further stratified the sample by firm size, on the assumption that occupational structure is markedly influenced by this variable. Sampling then followed this pattern:

Firm Size	*Sample*
100 or more	All Employers
20 — 99	Each fifth employer
10 — 19	Each 25th employer
0 — 9	No sampling

Heavy weighting to larger firms within each strata was justified on grounds that such units would exhibit the broadest possible diversity of occupations. Exclusion of the smallest firms rested on the assumption (supported by past agency studies) that firms in the zero to nine employee class differ little in occupational structure from firms in the 10—19 employee class.

To this point, methodology of the Ventura Project differs little from other such surveys. An interesting feature of this study, however, was an attempt to anticipate the impact of new firm development on the area labor market. Researchers sampled firms known to be planning new units in the Ventura area, seeking their projected occupational needs.

Questionnaire design normally separates employer estimates of current needs from forecasted future needs in two and five years. This study was no exception. Total forecasted employment was constructed from separate employer estimates of replacement demand (generated by retirements, deaths, and job changes, but excluding quits) and expansion demand (new job openings because of new business or changed technology). Questionnaires normally include job title descriptions taken from the *Dictionary of Occupational Titles* (DOT) (1965) to provide comparability of employer response.

Respondents received questionnaires by mail, and the vigor of follow-up varied considerably. The Ventura Project, through intensive follow-up procedures (letters, phone calls and the like) secured a respectable response rate of 95 percent of the original sample.

Data secured on replacement and expansion totals are combined across employers to yield occupational "demand" projections ("requirements" in Hansen's (1965) terminology) for the "short run" (two years) and the "medium run" (five years). An assessment of this kind will hypothetically furnish manpower-oriented agencies with information needed to plan occupationally-specific training and education.

Data generated by this process may be weak because questions are not well put, because the justification for questions is not clear, or because employers can not or will not answer.

Use of a mail questionnaire increases the likelihood that employers will misunderstand the questions that are asked. Researchers for Project VISION (Fischer, 1970), an intensive effort by the Wisconsin State Employment Service to evaluate various forms of manpower forecasts, found that employers confused occupational categories as defined by the Manpower Administration's *Dictionary of Occupational Titles* (DOT). Employer classifications, often based on internal needs for departmentally-oriented terminology, were frequently substituted. Replacement demand tended to be poorly understood by employers, leading VISION staff to recommend use of a simple request for estimated loss due to retirement. Some area skill surveys attempt to isolate technological trends by asking employers to identify "emerging occupations," the relative importance of

which will be expected to grow in the near future. Employers generally found this category confusing and ignored it.

Area skill survey questions on employer training activity tended to generate little response, VISION researchers found. It is probable that unstructured training activity, prevalent in most occupational categories, escaped employer notice, leading to a natural propensity to underestimate on-the-job training as a source of skill formation.

From an economic point of view, questions which ask an employer to project requirements without stating some assumptions regarding the course of other variables in the system may yield ambiguous answers. It may not be clear, for example, that an employer makes his projections assuming a given job category pays the same relative wage now and in the future. Moreover, the "threshold" beyond which it pays an employer to substitute alternative techniques rather than pursue hard-to-secure personnel may vary across time, industry and occupation.

The quality of employer responses may reflect the costliness of securing information the survey requires. Few employers systematically plan manpower needs, even for a one-year period.[1] Individuals made responsible for filling out skill survey forms may not possess the knowledge required to furnish complete data. Again cost considerations may deter an employer from assigning this task to the person(s) most qualified for it.

Lack of data from firms scheduled to open during the forecast period, plus inability to predict bankruptcies and plant closures, will distort the results. Information on announced plant openings gathered in the Ventura surveys obviously adds useful data, but fails to account for unannounced openings and unanticipated closings.

Labor market pressures appear to have no impact on employer interest in planning or in participating in skill surveys. Project VISION found that 74 percent of non-respondent employers in an area skills survey had "experienced" serious "shortages" in the external labor market. (Terms in quotes are ill-defined, and VISION's conclusions are weakened by the absence of a comparison of respondents with non-respondents). Non-response may relate to the prevalence of internal promotion practices, (VISION reports 59 percent of non-respondents relied on internal sources, but again, unhappily, no comparison with respondents appears in the study). VISION researchers surmised, on the basis of experience with their trial survey, that many employers, lacking complete and current records, guessed at present demands and projected these guesses into the future. Some employers simply prorated, for each occupation, an estimated percentage change in over-all employment for the firm.

A further source of bias arises from the nature of occupational and industrial classifications used. If occupations are non-homogeneous within industrial

1. VISION researchers found that 16.5% of respondents in a special area skill survey did some manpower planning. Only 12.5% of contacted non-respondents planned manpower needs, a difference that is hardly significant. Another study, by Heneman and Seltzer (1968), observed that out of a sample of Minnesota's largest (500 or more employees) firms, 72% forecast all or some of their manpower needs, but only 36% bothered to forecast the available external supply. For other discussions of manpower planning at the firm level see U.S. Department of Labor, *Employer Manpower Planning* (1970), Wilson (1969), and Saltzman in Weber *et al.* (1969).

groupings, a low response rate can yield serious misestimations of the true values. Expansions from a sample to the estimated universe based on partial response from an occupationally-heterogeneous industry can lead to absurb forecasts. Presumably, occupational homogeneity should increase as more finely-defined industrial categories are used (e.g., 4-digit rather than 2-digit) but care must be exercised with any classification system. (See below for further comments on classification schemes).

In summary, occupational information from area skill surveys varies in detail, according to the employer's understanding, his own classification scheme, and the skill with which Bureau of Employment Security analysts translate survey data into *DOT* classifications. With further effort, the interested vocational education planner could translate *DOT* groups into vocational education curriculum clusters, using the U.S. Department of Health, Education and Welfare *Vocational Education and Occupations* (1969) as a source. This process is not presently a routine feature of area skill surveys.

It is difficult to evaluate the accuracy of area skill survey forecasts relative to other techniques, since little evaluative work in this area has been done. Standard accuracy analysis has been applied to an area skill survey in New Jersey (see Rutgers, 1966). It was found that discrepancies between predicted and actual total requirements were reasonably small, but that predictions for more occupationally — and industrially-specific categories showed greater tendency to vary from actuals.

Collette Moser (1971) applied statistical tests to determine the accuracy of two-year skill survey forecasts done in Roanoke and Petersburg, Virginia in 1964. She compared "prediction loss" (squared difference between predicted and actual values) of the skill survey technique against two naive models: a "no-change" model and simple application of the 7 percent state employment growth projections.

The skill survey projections outperformed no-change naive models for both cities in forecasting total employment change. In Roanoke, however, the skill survey forecast was outperformed by the 7 percent change model. In predicting occupational change using skill survey data, as one might expect, success proved greatest in Petersburg, where the skill survey aggregate forecasts was more accurate than the naive growth model. Even here, however, in roughly one-third of the occupations considered, naive models provided superior forecasts. The naive and skills survey forecasts performed equally well in Roanoke.

By implication, this study suggests that a naive growth model does about as well as a skill survey in forecasting an area's total employment needs. Moreover, though the skill survey seems to give superior forecasts at the occupational level, the results are not unambiguous. Clearly, evaluation of repeated forecasts in a given area, as well as broader geographical coverage, would improve our understanding of the skill survey technique's accuracy.

The area skill survey has definite strengths as a tool for manpower forecasters. If carefully used and periodically evaluated, the survey yields a volume of data invaluable for the analyst of local labor markets. Employer surveys, in most instances, must fill the gap created by the absence of intercensus occupational data. Moreover, if researchers take pains personally to contact and involve employer respondents in the process, as suggested by VISION re-

searchers, improved understanding of the forecasting function may strengthen employer commitment to "think ahead" in this area.

On the other hand, by itself the area skill survey is a poor forecasting tool. The staff researcher substitutes the employer's forecasting model (which is unknown, varies from individual to individual and may be logically fallacious) for his own. Employers may be unable to put together accurate forecasts, and indeed, they have no particular motivation for doing so (it costs an employer nothing to forecast large requirements in a hard-to-fill category, even if internal policy changes could eliminate the problem). Requirements studies may, themselves, influence outcomes by altering behavior of various supply institutions, but the area skill surveys furnish no systematic data on supply sources for various occupations. Finally, the area skill surveys fail to meet two important standards for forecasting mentioned above: Their structural logic is unclear and their assumptions are largely unstated.

Studies done explicity for vocational educators, particularly involving non-farm rural occupations, have made use of assumptions and techniques essentially similar to those used in Area Skill Surveys. Examples include Barwick *et al.* (1965), Bailey (1965), Masley (1966), Wall *et al.* (1967). All make use of employer surveys designed to gather information on job titles and descriptions, as well as the current stock plus forecasted expansion in numbers of positions. Since in many cases vocational educators planned and carried out the interview and analytical phases, questions aimed at bringing out the curricular implications of changed manpower needs.

Because they are rather narrowly focused, studies of this kind yield more detailed data than do Area Skill Surveys. Their special value comes from increased understanding of the content and structure of a particular set of jobs.

Several other occupationally-specific employer surveys have been carried out on *ad hoc* bases. Oklahoma State University (1966) tried to develop information useful for curriculum planners and data inputs for manpower forecasters in the cluster "electromechnical technology." Their projections, based on a national sample, reflect no apparent structural model, and indeed the sampling procedures used are never clearly spelled out. The State of Idaho (1966) surveyed employers to secure data for forecasts, by area, of demand in metalworking occupations. Researchers made attempts to inflate sample data in particularly "critical" shortage occupations. This approach parallels a study done by R. Wilson (1968) of employers of architectural draftsmen. The *Michigan Technician Needs Survey* (Kelly, 1967) covers a broad cluster of "subprofessional" occupations, with a sample stratified by size (number of employees) and "type of product" (similar to the Ventura "strata," but less defined by occupational homogeneity considerations).[2] Bandes' Connecticut Study (1969) of industrial technicians relies principally on an employer survey, though supply-type information is sought from training institutions.

2. To adjust predictions in the face of a large non-response rate, staff members adopted the following convention:

$$\frac{\text{Employment in firms not interviewed (SIC)}}{\text{Employment in firms interviewed (SIC)}} \times \text{projected technician employment (interviewed firms)}$$

= Projected technician employment (firms not interviewed). This, of course, assumes the technician/total employment ratio is constant across firms.

Shortage studies in health manpower have frequently forecasted on a base of employer surveys. Pinsky and Lownds' study (1967) of health service occupations needs in Connecticut (forecast to 1976) uses a traditional area skill survey approach, including estimates of current employment, expansion needs, job vacancies and training requirements. A similar study of projected demand for nurses in southern New York State was done by the Hospital Review and Planning Council, (1967). Kehrer's study, in *Manpower Research Projects* (1970), of nursing shortages in Connecticut correlated employer perceptions of labor market shortages with standard shortage measures used by economists (wage relatives, turnover rates and the like). Statistical tests revealed little relationship. (D. Kidder, 1967, in a study of firm perceptions and responses in an Indian labor market, found a similar lack of correspondence between perceptions and shortage measures.)

These studies share the strengths and weaknesses of area skill surveys measured above, though their concentration on specific occupational groupings tends to make the employers' and analysts' jobs less complex. On the other hand, variable and often unstated assumptions and methodology ("home-baked" techniques, a phrase used by Stein and Cho-Kin, 1966) make it difficult to evaluate the replicability of such studies in different contexts.

Medvin's "Unfilled Openings" Model

Another forecasting system spawned by the availability of employment security data, the "unfilled openings-industry-occupational matrix" approach, (or "openings-matrix") was developed by Norman Medvin (1967, 1969) of the Bureau of Employment Security in the middle 1960's. We can specify the indicator of "shortage" implied in Medvin's approach in the following manner:

If $\frac{\text{Listings unfilled (30 days or more)}}{\text{Total listings}} \times 100 > s$ ("intensity") then a "shortage" of some degree exists. "s" represents a judgment criterion that establishes a shortage threshold for a given occupation. Its absolute size varies across occupations.

Medvin (1969) describes the assembly of data for classifying 100 "shortage and high acitvity jobs," and presents a sample list for Hartford, Connecticut in a paper presented at the Ohio State Conference on Manpower Information for Vocational Education Planning. The data base includes qualitative projections of the *Occupational Outlook Handbook* (BLS, 1971) and quantitative occupational projections of the Bureau of Labor Statistics' Industry-Occupational Matrix (both discussed below). Absolute numbers of 30-day unfilled openings are presented as interval estimates, based on successive quarterly measurements. "Intensity" of shortage follows, as defined above. Finally, qualitative estimate of employment growth for the occupation is included (Rapid = 25% or more; moderate = 15-24%; slow = 5-14%; little or no change = less than 5%; decline = 5% or more decrease). Percentages presumably cover the entire forecast period (1968-75 in Medvin's examples), and are based on national projections. In local applications, Medvin emphasizes that vocational education personnel, guidance

counselors and other interested parties were used to "refine" the national rankings of occupations.

Finally, unfilled openings data are combined with data from job vacancy series, which will soon be available on a regular basis for 32 metropolitan areas, collected under the Manpower Administration/Bureau of Labor Statistics Program (see *Manpower Report of the President,* 1971, p. 181), and supplemented on an *ad hoc* basis by state collections. Hypothetically, vacancy data can be used to check the representativeness and coverage of Employment Service unfilled openings data, and can provide a factor to "blowup" unfilled openings figures for occupations when areawide projections may be desirable.

Medvin characterizes the result as a measure of "the net inability of the community to find workers, the residual after all the various manpower actions have occurred in the market place" (Medvin, 1969, p. 9).

From the administrator's point of view, this technique represents a systematic and uncomplex way of applying a storehouse of previously unorganized data to the forecasting process. Unfortunately, however, as Medvin points out, not all states collect unfilled openings data quarterly for states and Standard Metropolitan Statistical Areas (SMSA's). Even fewer local areas are covered by regular, comprehensive job vacancy surveys. To realize the cost advantage Medvin claims for his approach, local administrators must continue, in most cases, to rely on national occupational projections, unless state or area industrial-occupational matrixes exist, or an occupational outlook-type projection has been made.

As is well known, employer registration of vacancies with state employment service offices depends on the state of the market and on institutional features of information and recruitment systems for different occupations. Certain jobs linked tightly to recognized supply sources, for example, aviation technicians or dental technicians will not show up in employment service data even under conditions of shortage. Employer decisions to register a vacancy may be conditional (a vacancy exists if a number of side conditions are fulfilled) and hence prove difficult to interpret in raw form.

The Medvin approach does yield occupationally-specific data, though the need of local forecasters and availability of national trend projections may vary. National two or three-digit projections may have to be applied to local distributions better described at the four-digit level, because of a peculiar industrial mix. Once again, of course, subjective judgment by knowledgeable officials becomes an invaluable part of the process.

To this author's knowledge, no attempts have been made to check the accuracy of forecasts made using Medvin's technique, partly because such forecasts do not appear in a form readily analyzed. Interval estimates of current shortages, combined with national trends, do not yield hard data but rather portray directions and trends, subject to continuous revision. It is more important, in Medvin's mind, to pinpoint occupations of continuing shortage rather than project exact quantities for a broad range of jobs.

The strengths of the Medvin technique lie in simplicity of form and comprehensibility of language. In gross terms, an occupation subject to persistent "intense" shortage probably does deserve attention from relevant officials. The

intensity ratio, or even the range of absolute unfilled openings, can perhaps be a useful indicator, to policy-makers, of market failure.

But an indicator based on a largely unstructured model cannot tell us why a situation exists or what kinds of policies can change the situation. If, for example, the intensity ratio for auto mechanics declines, is this due to a supply change (increased numbers of qualified mechanics) or to a demand adjustment? Employers may simply alter production techniques to minimize the use of a scarce occupation, or cyclical fluctuations may temporarily change the production picture, and hence occupational magnitudes, for the whole industry.

An indicator of this kind simply creates its own demand for further information. By ignoring explicit supply forces (shortage or surplus implies mismatched demand or supply), Medvin's approach begs a number of supply-type questions. What role does migration play in filling demands? How elastically does the training and vocational education industry respond to demand changes in specific occupational areas? How substitutable is on-the-job training, as a supply source, for more formalized preparation, such as apprenticeship or technical schooling? How do relative wage levels, and changes in these relationships, alter supply forces? On the demand side: How do employers adjust their production techniques, recruitment and training methods in response to continued unfilled openings?

By failing to limit the scope of inquiry in an identifiable model, with clearly limiting assumptions, Medvin leaves the policy-maker unable both to check the accuracy of a forecast (of the descriptive variety) and to estimate the effects of policy designed to alter a forecasted result (Hansen's "outcomes with responses," 1965).

We have commented on limitations forced on employer survey forecasts by poor data bases. Medvin feels that absence of job vacancy surveys and limited registration of unfilled openings in some occupations constitute the most serious data problems. Probing for further weaknesses in employer-based data, an experimental unfilled openings project launched by VISION to test the Medvin approach yielded interesting feedback on employer information sources. Employers again found difficulty in matching their occupational categories to those of the *Dictionary of Occupational Titles.* There was a considerable confusion over the skill dimension applicable to a given job title (Machinist A and B, for example). Furthermore, employers found it extremely difficult to project their own knowledge and experience to the entire labor market. This conservatism probably reflects a sensible unwillingness to build a structure of shortages for an area in the image of the firm's labor market.

In light of Medvin's suggestion that local "experts" be brought into the process, it seems reasonable to ask how much better his technique performs than, say, the informed judgment of a panel of industry people, guidance counselors and vocational education personnel. To this author's knowledge, no such test has been made. Project VISION's "industry-expert" technique uses an industry rather than an area-wide focus, which makes it inappropriate for a direct test of performance against the unfilled openings method. The VISION technique utilized a broad data base, including unemployment compensation figures, output from the unfilled openings study conducted by VISION, interviews with industry

personnel, Bureau of Labor Statistics (BLS) industry manpower studies and material from their *Occupational Outlook Handbook* (1971). Staff members felt that concentration on a definable industry made possible more sensitive occupational classifications, subdivided by skill level for example, than did studies with an area focus. Lack of geographical orientation, however, limits the usefulness of this technique for many forecasters whose mandates require state or regional projections across a broad range of industries. It proved difficult to weigh the benefits of a gain in occupational/industrial specificity against the loss in forecasting generality. Moreover, though VISION staff consistently refer to the "accuracy" of this method, they make no attempt to gauge accuracy in a reportable fashion.

In summary, what we have chosen to call "unspecified" models, here typified by area skill surveys and the Medvin "unfilled openings" technique, are methods of collecting and arranging employer manpower information in ways that may suggest further analytical needs to forecasters. They are "requirements-oriented" tools, even though supply forces are implicit in Medvin's measures. They are subject to errors of unspecified and diverse forecasting techniques used by employers themselves, and to the vagaries of employment service registration. They are inherently short run in nature, depending for their "forecasting" properties on applied projections of more complex models such as the BLS matrix (p. 32). They are difficult to evaluate in the context of positive policy, since the way the system will respond to policy changes cannot be specified. It is, finally, not clear whether or not similar qualitative precision might be achieved at equal or less cost by periodically polling a group of experts (a version of the "Delphi method") about projected trends.

The vocational educator will, no doubt, continue to be dependent on skill survey sources for data on the job market. He should bear in mind weaknesses in the data base which have been outlined. He should remember that the very act of surveying may alter his forecasts. And he should decide whether or not his forecasting needs are fulfilled by a technique which produces no labor supply information.

The very conditions which cry out for sound forecasts, rapid and uneven occupational growth with or without alteration in job content, generally leave a regional sample of employers unable to make intelligent projections. Thus, the Area Skill Survey gives maximum results in a fairly static labor market, where little is known in advance about the existing occupational structure.

Medvin's indicators, on the other hand, allow the vocational educator to confirm hunches about specific occupational trends. Supporting data needed to explain the persistence of "intense" shortages must come from studies which reveal how the labor market for particular occupations operates.

The line which separates unspecified from specified forecasting techniques is blurred in the area of simple projections, extrapolations and the use of "indicators." However, we have chosen to group these methods in the category of "specified technological" models, though poor structural specifications and failure to state realistic assumptions may plague the potential user with these as with previously discussed techniques.

In summary simple projections and technological forecasts make few assumptions above the causes of change, and are usually fairly aggregative in nature. Trend projections normally hold productivity constant over the forecast period. Technology forecasts, such as those used in the *Occupational Outlook Handbook*, make use of intensive analysis of levels and trends in technology. "Paradigm" models (best plant, international comparisons) use existing "optimum" technologies as targets toward which the whole system is supposed to be moving. Realistic assumptions about changes in productivity are crucial to useful forecasts, and emphasis on examining components of technological change have led to reasonably sophisticated qualitative forecasts. The studies discussed have value as such for vocational education planners. Paradigm models probably involve less expense in preparation and use than do special technology surveys, but conceptual problems cited above limit their usefulness to a regional vocational planner. Occupational outlook-type projections probably offer a planner the most informed opinion on national technological trends available. Supplemental use of area experts' opinion should make application of this information to a local situation practical.

Technological studies may also furnish input into more sophisticated analyses, or serve as cross-checks on the validity of other estimates. It is impossible to say whether or not they are more or less "accurate" than forecasts from area skill surveys or unfilled openings studies, since no comparative studies of this type have been made.

"UNSPECIFIED TECHNOLOGICAL" MODELS

Most forecasting models are "technological" in nature. According to this designation, crucial production ratios, e.g., technicians/employment, labor/capital are fixed for the forecast period or change according to some predetermined pattern. In a model of this type, changes in relative resource costs will not alter the way businesses produce goods and services (how much of what kind of input is purchased) or how much of what kind of input is offered to the productive system. Production relationships are fixed by technological considerations, not economic considerations (price, cost or wages). One of the simplest types of technological forecasts involves extrapolation of a linear trend. Complex examples include input/output models, the technical coefficients of which are fixed, and labor market "systems" which compute supply-demand balances based on identity equations.

Demographic models of population change, which project changes in age-sex components of the population over time, serve as inputs into the projection process. Literature on demographic projection and on curve fitting may be found in Morton (1968).

Naive Models, Trend Extrapolation

Naive projection models may be of three general types:

1. Thoroughly naive: projected (next year) = actual (this year)
2. Constant absolute change: projected (next year) = actual + actual absolute change this year.
3. Constant relative change: projected (next year) = actual + (actual x percent change this year)

Data needs depend on the job at hand, as does the degree of occupational specificity achieved. John Norton (1967) tried to test the accuracy of labor force projections for several metropolitan areas, concluding that for certain purposes, the best forecast resulted from an average of techniques 2) and 3) indicated above. The operational significance of this result is not clear, but there is no logical reason for such a result.

Johnston and Methee (1966) illustrate a sophisticated version of the absolute change trend-fitting approach in deriving state projections of labor force participation from national data.

T = trend (in 10 year intervals)
SR = state labor force participation rate (by age, sex and color)
NR = national labor force participation rate (by age, sex and color)

Subscripts identify the year.

(1) $T_{40\text{-}50} = (SR_{50}/NR_{50}) - (SR_{40}/NR_{40})$

(2) $T_{50\text{-}60} = (SR_{60}/NR_{60}) - (SR_{50}/NR_{50})$

Computed trends are then applied to forecasted trends, with weights (arbitrary absolute values) that put more emphasis on the most recent decade.

(3) $T_{60\text{-}70} = 1/3\,(T_{40\text{-}50}) + 2/3\,(T_{50\text{-}60})$

(4) $T_{70\text{-}80} = 1/3\,(T_{50\text{-}60}) + 2/3\,(T_{60\text{-}70})$

Using the values in (1) to (4), solve for SR_{70} and SR_{80}.

As a check, these rates are compared with "acceptable limits," created by averaging the four highest and four lowest state rates and checking for trends in the limits. Finally, participation rates and popualtion are combined to yield age-sex-race specific labor force projections. Indiana's Terre Haute forecasts (1966) illustrate the application of state percentages to project metropolitan figures by a similar trend method.

Simple linear trend projections, wherein historical data are fitted visually or through least squares regressions and forecasted values represent straight line extrapolation, are quite common in the literature. See, for example, Massachusetts Division of Employment Security (1970), State of California (1965) and Northern Natural Gas Company (1965). In contrast to the unspecified models discussed above, these studies list assumptions. The State of California study, *Manpower for California Hospitals, 1964-1975*, illustrates types of broad assumptions applied: 1) assumptions regarding international affairs (course of the war, trade agreements, absence or presence of new conflicts), 2) technological change (none, trend), 3) impact of public policy, 4) population growth. The Department of Labor's Working Group on Manpower Projections (1967) criticizes the simplicity of many studies' assumptions: for example, zero technological change, constant occupational structure, or unchanging population growth. Nonetheless it is important to understand the context, however naively conceived, in which a forecaster expects his model to operate.

Labor force projections of the Mediterranean Regional Project illustrate the assumption of constant or trend forecasted technology. (OECD Planning . . . 1962; Parnes, 1962) From the identity:

$$\frac{GNP_t}{GNP_o} = \frac{L_t}{L_o} \times \frac{H_t}{H_o} \times \frac{P_t}{P_o}$$

where GNP = gross national product
L = employment (number of workers)
H = total hours worked
P = output/manhour (productivity)
Subscripts: Base year = o
Forecast year = t

One may derive forecasted employment as:

$$L_t = L_o \left(\frac{GNP_t}{GNP_o} \times \frac{H_o}{H_t} \times \frac{P_o}{P_t} \right)$$

Employment is related to change in production, hours and productivity, propositions which one may test econometrically, using historical data. A forecaster may use parameters derived from such a test to predict future values. Alternatively, GNP, hours and productivity may themselves be forecasted and plugged into the projection expression above. The Mediterranean Regional Project employment totals may then be subjected to further subdivision by occupation and industry, through use of an occupational matrix.

The Bureau of Labor Statistics' attempt to forecast technician requirements provides an example of technological projections based on key ratios. See U.S. Department of Labor, BLS, *Technician Manpower* (1966). See also "America's Industrial and Occupational Manpower Requirements, 1964-75" (1966) and Pearce, C.A. *et al., Technical Manpower in New York State* (1964). Using as a base total employment projections by industry, the BLS attempted to uncover system parameters that best explained changes in employment of technicians, subject to data limitations. Several tests indicated that technician employment related most closely to the employment of engineers and scientists in a given industry.[3] Final interval estimates, which checked the results' sensitivity to ratio changes, were included.

Since the BLS carefully elaborated the assumptions behind this set of projections, it would be instructive to examine the "reasonableness" of these assumptions in light of subsequent events. Researchers assumed, for the forecast period:

a. Three percent unemployment;
b. High real economic growth;
c. Continued growth in research and development spending, with some slowing at the margins;
d. High levels of defense spending;
e. Continued steady rates of innovation in industry;
f. No important change in occupational structure;
g. Markets "cleared" (no demand-supply imbalance) in 1975.

Assumptions a, b, and d, have proven to be unreasonable by any criteria during the past two years. Assumption c seems acceptable, though the braking effect created by decrease in government expenditure is more severe than anticipated. Assumptions e and f are more or less necessary to a technological model, however open to criticism on theoretical grounds. And, assumption g could (but does not) imply a specific policy response to forecasted shortage or surplus. This critique should make clear that knowing a model's assumptions improves the chances that the reasons for bad forecasts can be uncovered. Faulty assumptions can always be changed. Unstated assumptions offer no guidance to the user who hopes to improve a model's performance on the basis of trial projections.

Simple forecast exercises which project trends generate little primary data of their own, are usually national in scope and, except in special studies, are imprecise in occupational detail. Yet the vocational education planner can usefully apply knowledge of national trends to the local area if he carefully notes

3. This relationship of technician/engineer and scientist is a descriptive relation, based on observation of practice in industry. It should not be confused with "ideal" or normative ratios, sometimes used in employment projections when supply responses are expected.

assumptions used and the pitfalls involved in translating national to local patterns. At the level of occupational detail most vocational planners need, trend projection may or may not produce superior forecasts, as Moser suggests (see above). The technique is clearly less expensive than *ad hoc* employer studies. Unfortunately, our present understanding of what conditions favor choice of a trend forecast over a skill survey is quite limited.

Technology Studies, "Paradigm" Models

Variants of the simple projective model, which incorporate attempts more systematically to forecast technological change, include detailed technological studies, "best plant" forecasts and international comparisons.

The Bureau of Labor Statistics' series of industry technological forecasts, incorporated in projections of occupational structure for various industries such as health services (1967), design and drafting (1966) makes use of a wide variety of data sources. At the first stage, analysts examine published documents (e.g., company reports, government studies, trade journals). Then researchers conduct extensive interviews with experts and undertake visits to plants where technical change is thought to be occurring at a particularly rapid pace. A preliminary report estimates the future course of the labor/output ratio for the industry. At this stage, provisional employment projections are made. Finally, 10-15 industry experts review projections as a check on the "reasonableness" of the results.

Projections in the *Occupational Outlook Handbook* analyses make use of technological change information as well as forecasted natural growth or recession by occupational category. In this form, they are of considerable direct interest to vocational education planners who want occupationally specific information. Again, forecasters utilize expert opinion as well as written documents as bases for projection. Though qualitative in nature, projections in the *Occupational Outlook Handbook* have been subjected to analysis by Harold Goldstein (1963). Of the predictions, 75 of 108 proved "correct" in a directional sense (increase, decrease, no change), according to Goldstein's test of 1949 *Occupational Outlook Handbook* forecasts. Detailed analysis of technical change apparently allowed these forecasters to foresee reductions in employment that other methods failed to project. Failures in the forecasts, according to Goldstein, resulted from inadequate structural assumptions (blue to white collar mobility was seriously underestimated) and from a faulty census population forecast.

Technological forecasting has gained in sophistication in recent years, but an adequate theoretical explanation for changes in technology has yet to be devised. (See Lenz, 1962) Crossman (1965) points up the need for relating technological characteristics of an industry to employer tendencies to treat labor costs as fixed or variable, an important consideration in choice of internal versus external sources of manpower. Work by Crossman *et al.* (1966) at the University of California on case studies of technological change, aims at identifying the impact of technology on quantitative labor requirements and on the skill content of jobs. Haase (1966) asserts that all innovations likely to have an important impact on production within the next 10 years are now known, an assertion that

should prove comforting to the forecaster who lacks confidence in his ability to predict technical change over the long period. Haase discusses the importance of further research into how cost factors influence the rate and extent to which innovations are diffused.

"Best plant" forecasts identify an "advanced" firm and use its occupational structure as a guide in projecting an entire industry's occupational structure. The researcher assumes, of course, that a) a "best plant" can be identified; b) cross sectional data can be used to represent an essentially historical process (change in occupational structure over time); c) occupational structure relates to productivity.

Project VISION's "leading indicators" experiment sheds some light on Assumption a. Staff members tried to isolate characteristics of firms which might foreshadow changes in the technological (and, by interference, occupational) "mix" of an area. They explored three possibilities:

1. Capacity change indicators;
2. Change of product line;
3. Propensity to relocate.

In a mail questionaire, it proved impossible to define capacity. Some employer respondents used production; some used plant and equipment; and some used other measures specific to their industry. It should be noted that the argument among economists over a "best" measure of capacity is by no means settled. Among firms surveyed, there proved to be little evidence of product line change. More telling, perhaps, the methods employed to secure information could not include data on potential new firms. Finally, researchers observed little impact on occupational structure traceable to intra-market firm mobility.

Concerning Assumption b, the use of cross section data to measure historical forces has received treatment in the econometric literature. (See Johnston, 1963.) To employ this approach, one must assume that the passage of time, and changes in exogenous forces over time, will not alter the entire industry-occupational structure, measured as a slice of history by cross section methods. Obviously, a cross section of the "transportation industry" in 1870, best firm and all, would have yielded a poor prediction of industry technological patterns in 1920.

The relationship between productivity and occupational structure (Assumption c) remains largely untested. Work by Layard and Saigal (1966) shows significiant relation between productivity and proportion of total employment represented by professional, technical and kindred workers (based on comparison of inter-country data), but the relationship deteriorates as one proceeds "down" the occupational scale. Moreover, tests of this type involve categories too gross to be of use to occupational forecasters.

One may state similar objections to the use of international comparisons, a "best country" variant of the "best firm" model. Hollister (in Sinha, 1965) effectively argues that the assumptions required to forecast using the international comparisons method are too stringent to allow practical use of the model. These assumptions include: like demands, like technologies, fixed coefficients of production, identical rates of investment and no foreign trade (or perfect international product markets plus identical resource endowments). It

is doubtful that a vocational education planner in the United States would find this approach useful. Nonetheless, the interested reader may find data gathered and tabulated for this purpose in Horowitz *et al.* (1968) and OECD (1969).

Lawson (1970) and Lunde (1967) employ multiple tests to determine the "best" indicator of occupational change. Lawson's study of four service occupations in the Ventura County Standard Metropolitan Statistical Area (SMSA) matched indicators against multiple linear regression, ratio and graphical analysis. Unfortunately, he avoids passing judgment on the best general technique of the four tested. Out of a list of indicators, however, industrial and total occupational employment performed best as indicators for all four occupations, but each had a separate "best" indicator. Lunde's experiments proved even less conclusive. He found professional, technical and kindred workers' employment related to GNP, real GNP/worker, personal income, index of industrial production, the National Industrial Conference Board (NICB) Help Wanted index (see National Industrial Conference Board, 1970, and Cohen and Solow, 1967), non-agricultural employment, unemployment rate, proprietor's income and bank debits: After all this, he found that a projection based on his indicator list fared poorly in the early 1960's, when compared with a simple linear trend extrapolation.

Input-Output Models

The BLS Techniques: National Data

Input-output techniques, developed and applied in a number of planning situations, spell out the inter-industry relations of an economy in matrix form. Sectors sell goods and services to each other, and to final demand. The input of sector a into sector b may be expressed in ratio terms, and the resulting array of coefficients constitutes the "A-matrix." Labor, treated as a sector, sells a service to all industries and appears in the matrix in the form of direct labor contributions to each sector's production. An introduction to input/output techniques in a manpower context may be found in Burtle (1952). Recent developments in manpower forecasting from inter-industry models have followed the example of the government's Inter-Agency Growth Project.

The Inter-Agency Growth Project (described in Alterman, 1965) combines the resources of government departments involved with economic affairs (Labor, Commerce) with the expertise of a number of non-government economists to project output and employment for the United States. A similar model, developed in the United Kingdom, is described in Cambridge University (1964). Harold Goldstein of the Bureau of Labor Statistics has lucidly set forth the steps involved in a number of articles and papers. (Goldstein, 1963, 1969, 1971) The 4-volume publication *Tomorrow's Manpower Needs* (1969), from the BLS, spells out in detail the method by which output growth projections yielded manpower forecasts, and tabulates the forecasts themselves. Separate publications in the BLS bulletin series make use of the model's forecasts in specific areas (e.g., *Education of Adult Workers* 1970). Finally, the model has inspired replication at the state level (see especially the New York model discussed below), and served as input into area studies employing similar approaches.

The Inter-Agency model has been developed according to the following pattern:

1. Age-sex-race population projections, based on census data;
2. Age-sex-race-education labor force predictions. At this point, recent evidence based on careful econometric analysis of labor force participation rates is applied.
3. Estimated labor force (fully employed) generates a full-capacity level of GNP. At this point, the influence of other inputs enters in the form of assumptions about productivity change. (Compare with OECD technique, above.)
4. GNP broken down by expenditure group through the use of behavioral equations to explain consumption, investment and government expenditure;
5. Final demand and intermediate flows of goods and services allocated among industries in an input-output table, developed by the Department of Commerce, Office of Business Economics. Production estimates checked by econometric analysis of production in particular industries;
6. Production estimates and projected productivity changes (a BLS input) combined to yield employment estimates by industry;
7. Industry-occupational matrix applied to industry employment totals to arrive at occupational projections;
8. Occupational replacement needs estimated.

As a consistency check, the "supply" totals (labor force) from which the projection process derives should equal "demand" totals (employment derived from industry-allocated final and intermediate production).

It should be noted that the BLS approach introduces the supply forecast as foundation on which occupational projections are made, but does not project occupational supply, as such. Occupational requirements are fixed by the inter-action of supply and demand elements which yield a given occupational structure for a particular industry at a point in time. Thus, in the absence of independent supply data, this model cannot generate "shortage" estimates, since total supplies and total demands must balance.

Goldstein (1969) carefully points to the volume of detailed work on institutional and behavioral characteristics of labor and product markets which lies behind the model's development. Forecasted values based on this model are essentially sophisticated trend projections. It is the scale and quality of inputs into the model-building process that make the BLS-Inter-Agency forecasts unique.

Translating occupational categories into curricular terms familiar to vocational education planners requires use of the manual *Vocational Education and Occupations* (U.S. Department of Health, Education and Welfare, 1969). Goldstein (1969) discusses this procedure and presents sample tabulations in his paper presented at the Ohio State Conference.

The BLS Technique: State and Local Applications

Translating national industry-occupational projections into projections useful for local area planners depends on how readily available are local data. *To-*

morrow's Manpower Needs, Volume I, (1969) presents two methods by which BLS projections can be converted to area projections:

$L_{ij}(t)$ = local employment industry i, occupation j, at time t.
$L_i(t)$ = local employment in industry i at time t.
$f_{ij}(t)$ = national fraction of occupation j in industry i, time t
$L^*_{ij}(t)$ = local fraction of occupation in industry i, time t
$L_j(t)$ = local employment in occupation j at time t.

Method A (for use when no local industry-occupational matrix exists) (example is a 1960-75 forecast)

$$L_j(75) = \frac{\sum_i f_{ij}(75)\ L_i(75)}{\sum_i f_{ij}(60)\ L_i(60)} \times L_j(60)$$

Method B (for use when local industry-occupational matrix exists)

$$L_j(75) = L^*_{ij}(75)\ L_i(75)$$

where $L^*_{ij}(75) = \frac{f_{ij}(75)}{f_{ij}(60)} \times L^*_{ij}(60)$ – (base period local matrix)

A number of state manpower forecasts use the BLS approach. See, especially, Bognanno's (1966) discussion of the Iowa projections. Palomba (1968, 1970) and Spellman in *Manpower Research Projects* (U.S. Department of Labor, 1970), furnish additional examples.

New York State projections (see Berman, 1967) make use of state level industry-occupational benchmark data for 1960, and follow roughly the steps of the Inter-Agency model.

1. Estimate of labor force, by age and sex ("supply");
2. Estimate of non-farm jobs by industry (partial "demand");
3. Estimate of total (including farm) jobs (total "demand");
4. Reconciliation of 1) and 3), adjusting for unemployment;
5. Application of industry-occupational matrix to industry job totals, to obtain occupational distributions.

Log linear projections of New York/national employment by industry were used in computing forecast values. National (1960) and state (1960) industry-occupational matrixes were compared, and the BLS 1975 matrix projections were adjusted accordingly (Method B).

Project VISION developed its own forecasts, using the BLS matrix, by assuming that national industry-occupational patterns prevailed at the local level (Method A). Occupational projections were generated from regression equations, chosen to provide (for the historical data tested) low standard errors, "reasonable" regression coefficients and high coefficients of multiple correlation. For consistency, employment totals generated this way were checked against employment totals created from projected labor force participation rates times projected population.

The data base employed in BLS projections, organized according to census and SIC classifications, is open to conceptual criticism. SIC classification based on product make difficult the process of industry-occupation matching with

census occupational groups, based on process. Moreover, the aggregation requirements, along occupational or industrial dimensions, of national input-output studies seriously limit the usefulness of the matrix for local planners. Most areas boast special problems which call for analysis at the four or five-digit level. Even if this were not so, a local planner should exercise considerable caution before applying Method A to solve his forecasting problems. True, this method assumes that it is occupational changes, not structures that are comparable between the area and the nation. Neither assumption has any necessary *a priori* logical basis, however. Area size and industry homogeneity are but two factors which should affect the comparability of national and local patterns.

Input-Output: State Model

Another use of an input-output framework to project occupational employment appears in a West Virginia study by Miernyck *et al.* (1970). Here, researchers developed a full-scale model of the West Virginia economy.

A = normal A-matrix (inter-industry input coefficients)

E_i = quantity of labor used by sector i

X_i = output of sector i

$L_i = E_i/X_i$ = labor input coefficient, sector i

L_i represents labor purchased from households, a coefficient which reflects *primary* labor inputs.

$L \times A = L_{(int.)}$ (intermediate labor coefficients)

$L + L_{(int.)} = \overline{L}$. (matrix of total labor input coefficients -- *direct* labor coefficients)

To project employment to 1975, it was necessary to project sales to final output and compute direct and indirect man-hour requirements that these sales implied.

Rather than invert the L matrix, which makes no logical sense, researchers used the following approach to estimate requirements:

$\hat{L}$ = diagonalized matrix of primary labor inputs;

$(I-A)^{-1}$ = direct and indirect output requirements;

so $\hat{L}(I-A)^{-1}$ = direct and indirect labor requirements/dollars sales to final output.

Given final output projections, forecasted employment by industry and occupation followed the procedure of the Bureau of Labor Statistics. An industry-occupational matrix, with 50 broad occupational categories, was developed for the state and applied to industry totals to secure occupational projections.

Researchers painstakingly assembled a data base for this study through firm interviews and search of available data. Choosing appropriate assumptions about technological change reflected the availability of plant-level primary data.

Researchers adopted a "best firm" assumption (based on productivity comparisons), and used it to develop a target A-matrix for 1975.

As mentioned above, a best-practice assumption may or may not be reasonable, even without a time specification. In this case, the authors have added the restriction that average coefficients will reach the ideal industry ratios by the target year, a highly questionable assumption.

Projections based on single year benchmarks, characteristic of many forecasts, may yield faulty results because of disturbances and distortions present in the base year. Benchmark averages would eliminate some of this bias, but due to data-collection problems, probably the best that can be hoped for is periodic revision of benchmarks to achieve currency and check the representativeness of the base. Researchers in the West Virginia study derived a 1965 "benchmark" by linear interpolation from 1960-1975 BLS employment data. In the absence of direct observation, this approach has merit, but it would seem that accuracy and reliability of benchmark data should be a paramount goal.

Finally, after constructing an elaborate, dynamic input-output model, in which matrixes of replacement and expansion capital coefficients permit production for capacity expansion to be solved internally, manpower projections were made through the more traditional static approach, wherein capital sales are exogenously specified. It would have been interesting to compare employment projections generated by these alternative solutions.

Input/output projections which utilize primary state data are costly and time consuming to develop. For this reason, vocational educators who must produce forecasts of their own must normally depend on less exhaustive procedures. Nonetheless, the consistency required of a well-constructed input/output model should increase accuracy in the resulting projections. Once again, however, tests for accuracy on state input-output models remain to be done.

Occupation Education Requirements Analysis: An Alternative to BLS

The Occupation Education Requirements Analysis (OERA), authored by Morsch and Griest (1967), resembles the BLS occupational forecasting system, but carries the process further to project the expected educational requirements for the target year. See also Nussbaum, Morsch *et al.* (1969). OERA's data base is the set of projections developed by the National Planning Association (NPA), which gives sectoral production and employment requirements projected from a model that does not incorporate inter-industry flows. These projections are broken down by state and metropolitan area for the United States, and OERA's focus is similarly local in nature. Occupational projections, obtainable from the BLS industry-occupational matrix, are then combined with the Census Bureau's 1/1000 tape (1960) to yield a cross sectional picture of educational distributions by occupation. (Occupational projections are adjusted for attrition.) In a paper delivered at the Ohio State Conference, Nussbaum, Morsch *et al.* (1969) add the step of estimating grade level estimates of educational requirements.

OERA's data base is similar to that available to the Inter-Agency Growth Project, though BLS employment data differ from census figures used by the National Planning Association, (below). It is clear, however, that the NPA and OERA researchers have chosen to use this base differently (an explicit local orientation) than has the BLS in its early projections. Moreover, the conversion

to educational classification leaves results of the NPA-OERA exercise more readily usable for educational planners.

Morsch notes that occupational projections based on the NPA model are difficult to compare directly with BLS projections, because of coverage discrepancies between census and BLS data. Early tests indicate a tendency for the model to underestimate the growth of health occupations, but this failing is by no means peculiar to OERA.

Users of OERA forecasts should be aware of the NPA model's limitations, and should remember that implicit in this approach is an assumption that the educational distribution characteristic of an occupation now will prevail in the target year. This is not a necessary assumption of the model, even though we lack an explanatory framework for predicting changes in occupational-educational distributions. Future projections might usefully incorporate weighted trends to project change in educational distributions based on observed historical data.

Community Economic Base Studies

Community economic base studies are related in spirit to the input/output technique we have discussed, but are specially fitted for local area planning. Charles Tiebout (1962) wrote the classic reference for this technique.

Base studies treat the local area as a trading unit, engaged in importing and exporting goods and services. By assumption, industries that produce for export to the outside are prime economic movers in the community, and the researcher should try to identify key exporters. Other industries can be expected to react to changes in the export sector. Discovering these principal sources of employment and income will lead to a fuller understanding of the system that generates all community income and employment.

Tiebout discusses techniques for securing a sectoral breakdown.

1. Create an export sector by assumption, obviously a second-best solution.
2. Examine the quotient Industry employment (production)/Total employment (production) for the area and for the nation. If the area quotient exceeds that national quotient, then it can be assumed that the industry is an exporter.
3. Make use of Interstate Commerce Commission data on railroad freight haulage across state lines (a technique with obvious limitations for certain types of studies).
4. Undertake a direct survey (similar to the survey done for the West Virginia input/output study).

Total income changes in the community are then a function of increased "exports" (and/or increased local investment income) times a "multiplier", 1/1 — (marginal propensity to consume (locally) x income created/$ of local consumption sales)

Income increases generate total employment increases, and from this, hypothetically, an occupational projection can be obtained by using an area industrial-occupational matrix or by applying the BLS national matrix. General examples of applied community base studies, with employment projections, may be found in Hansen *et al.* (1961), Berman *et al.* (1961) and Hamburg (1964).

The methodological and empirical work of Harms *et al.* (1966, 1967) in Pennsylvania and in a small-area case study in Silver Bow County, Montana illus-

trates a base study application specifically aimed at projecting manpower. (See also McLean's 1966 study of Oregon, the economy of which is described in a system of equations depending on employment in the lumber industry.) The Harms approach depends on identifying "key industries," the fortunes of which are transmitted into local area trends. Harms recommends the assembly and analysis of supplemental data to support final employment projections, such as wage relatives, changes in hours, productivity figures and the like, when available. He offers no systematic framework for relating such data to the projection process, however. Once data are amassed, the forecaster selects the best projections of historical employment trends, using his knowledge of forces at work in key industries and, presumably, a judgmental analysis of supplementary economic forces.

Ferber and Sasaki (1966) apply the base study model to Hawaii which, by geography, perhaps best typifies the isolated trading unit dependent on exports. Their assumptions were simple, though probably adequate for a three-year forecast:

1. No change in the international stiuation;
2. No major new industries would locate in the state.

Export industries were identified, and their activity was related to changes in external variables (e.g., income in mainland U.S.). Then home sector employment was estimated in the following way:

$$\text{Home sector employment}_{(\text{sector 1})} = f\ (\text{Export activity, productivity in home sector 1, employment in other home sectors})$$

This model was applied successively to each of eight home sectors (the solution was not simultaneous). Projections of the model were tried in many forms, but on the basis of "reasonableness" of signs and coefficients, size of standard errors and R^2's, a log form was chosen. No attempt was made to forecast detailed occupational categories.

The authors checked the accuracy of their forecasts, using a measure of relative error (predicted -- actual/actual), against two naive models, comparable to models 1 and 2, mentioned above in the discussion of Norton (1967):

a) $\text{Employment}_{t-1} = \text{Employment}_t$

b) $\text{Employment}_{t-1} + (\text{Employment}_{t-1} - \text{Employment}_{t-2}) = \text{Employment}_t$

Happily, the base model outperformed both naive models, except in certain specific industries. Largest errors occurred in the smallest sectors, a result which plagues disaggregated forecasts generally. Total employment projections over the three years of the model lay within one percent of the actuals.

Inter-industry studies, of the community base type or of a more comprehensive nature, detail the income and associated employment structure of an economic system. Projections derived from them should be consistent, in the sense that no one sector can grow more rapidly than the constraints imposed by the other sectors will permit.

Again, however, it is not clear that occupational structure projections made on an input/output base will be superior or inferior to projections made through

other models, such as the OERA variant. Further tests of model accuracy should be made, as targeted years are reached. Input/output models often require industry sectoral aggregation that may not be of help to occupational forecasters. Here we should note the common tendency to lump together vast aggregations of service activity ("health services") while subdividing data from manufacturing industries at the two or three-digit level. Though the structural features of most input/output models are reasonably clear, it is still important to specify assumptions, particularly regarding changes in technological coefficients. Finally, from the local forecaster's point of view, the process of collecting and tabulating data in any useful detail for an input/output study is time-consuming and expensive. Elapsed time in data collection can introduce serious distortions into benchmark productivity data, since productivity fluctuates over the business cycle and, in some industries, according to a seasonal cycle as well. The community base study, or some variant, may offer a less costly way of spelling out local industry structural characteristics. On the other hand, vocational educators who must produce forecasts may find adaptation of the Bureau of Labor Statistics' national projections to local needs a tempting possibility. To be useful, however, such a technique requires considerable supporting evidence, such as Medvin's unfilled-openings data or technology studies, as well as liberal amounts of informed judgment from individuals knowledgeable about local conditions.

Systems Models: Basic

Systems models of area labor markets make use of "technological" assumptions employed in simple projections and projections based on inter-industry studies, but they represent, in addition, attempts to detail the broad "supply" and "demand" forces responsible for yielding a particular "net demand" ("shortage" or "surplus") at some future date. Supply and demand do not enter these systems as behavioral equations but as fixed totals available and/or required in the target year. Systems approaches chart the "total picture" of a labor market, but do not try to explain or predict behavior through an economically-structured model. We shall consider three examples of the systems approach, in its basic form: the Battelle Institute's Michigan study (1966), Arnold's Pennsylvania study (1969) and Braden *et al.*, Occupational Training Information System (OTIS) (1970).

Michigan Study

The Michigan Study, an attempt to forecast occupational manpower needs over a period of 15 years, was designed to develop estimates of future labor demand by industry, occupation and educational attainment, and estimates of future labor force by age, sex and educational attainment. Reconciliation of these "independent" estimates comes in an occupational/educational matrix that indicates whether or not the supply of labor (by occupation and education) will meet industry's occupational/educational demands. Imbalances would be termed "shortage" or "surplus." Implicit assumptions, which seem unrealistic for a 15-year planning period, are that Michigan's industrial character will remain largely

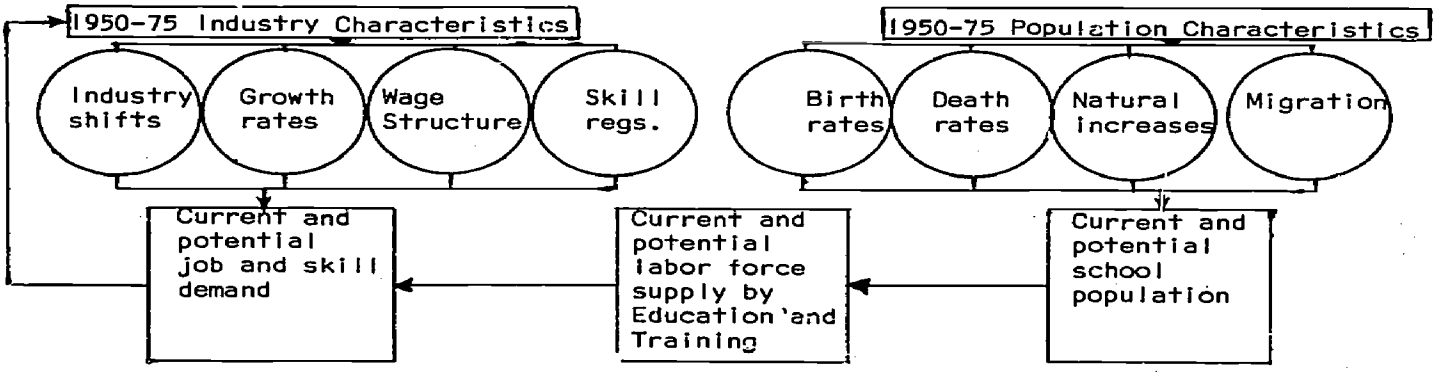
unchanged and that the educational distributions of various occupations will remain unchanged.

General educational categories used would not be of direct use of the vocational education planner. Further conversion to a curricular base would be required. Furthermore, it is clear that supply and demand by educational category are not independent, when computed in the manner used for this study. Employers make do with what educational attainment is available. As a result, a cross sectional occupational/educational matrix is the resultant of supply and demand forces. This comment applies, of course, to other models which project the current educational distribution into the future.

Arnold's Pennsylvania Study

Arnold's study of the Pennsylvania vocational education system concentrates on a part of the total system of interest to vocational education planners and, in contrast to the Michigan study, involves close analysis of the adequacy of institutional supply sources (especially vocational and technical schools). See also McNamara's *(American Vocational Journal,* 1971) discussion of this model. In flow chart form Arnold's system appears as in Figure 2.

Figure 2
A Flow Chart Model of the Pennsylvania System
(Arnold Study)



Projections are made by applying BLS national change factors to state-level occupational distributions. Needs by year are filled in by employing straight-line projections.

Arnold adds a thorough analysis of socioeconomic trends that might be expected to alter Pennsylvania's industrial and occupational structure. Categories in this phase of the analysis are circled in the flow chart model.

Analysis of the curriculum and capacity of existing vocational-technical programs is supplemented by an employer survey to determine: 1) the extent of employer training, and 2) the employer's use of vocationally-educated personnel.

Data for this study, which merges census and BLS figures with primary local data, are much more comprehensive than those assembled for the Michigan study, as suits Arnold's more ambitious design. At times, however, it becomes difficult to assimilate and use analytically the mass of information Arnold dev-

elops. There is a persuasive argument here for tighter logic in developing the model, perhaps with greater use of symbolic presentation. Nonetheless, of all studies thus far discussed, Arnold's contains the most thorough consideration of institutional supply forces -- a feature which should be of interest to vocational education planners.

OTIS

The Occupational Training Information System (OTIS) represents a departure from previously discussed models in four major respects:

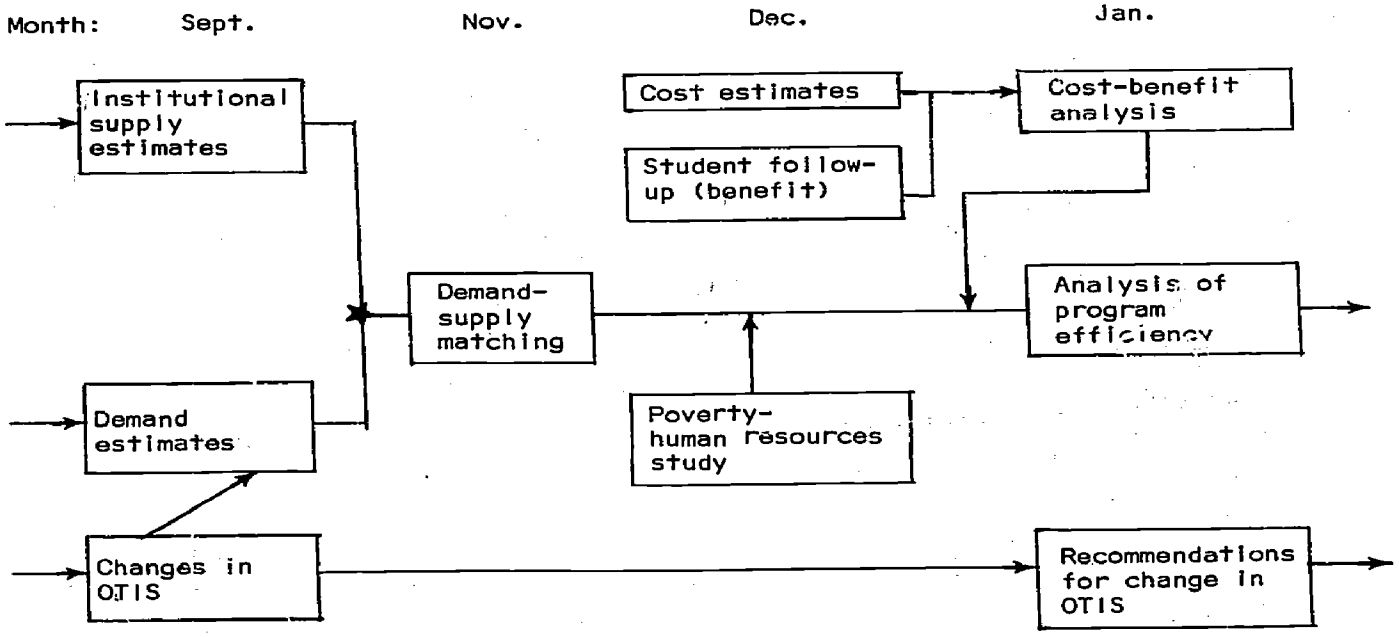
1. A technique for continuing critical self-evaluation is included.
2. The system is designed along a time dimension, recycling each year.
3. The model incorporates a recognition of the inter-action between forecasting and the sociopolitical environment.
4. The model includes a subsystem which relates the labor market to "disadvantaged" workers.

Because of its unique features, the OTIS model will be discussed in some detail here.

Figure 3 represents a simplified version of the flow diagram found in the OTIS Final Report (1970). A regular collection of supply data from public and private (an innovation) vocational education institutions would be accompanied, once the system is functioning, by demand reporting from employers. "Industrial coordinators," personnel from the vocational education system, are to be used to secure employer information. Non-institution supply sources (the unemployed, and the individuals learning skills on the job) are to be estimated from records of the state employment security office. Matching demand and supply information by occupation will be followed by development of educational curricular implications through use of *Vocational Education and Occupations* classifications.

Figure 3

A Flow Chart Model of the OTIS System



Current and projected state and regional imbalances, by occupation, will be calculated. The system should yield supply-demand parameters, along with parameters developed in cost-effectiveness analysis of the system. As part of the process, an Advisory Committee, which includes employer representatives, education officials and OTIS staff, monitors the process and recommends needed changes.

Since OTIS represents an attempt not only to forecast manpower requirements but also to develop a state-level information system, primary data used in an illustrative exercise were generated from institutional surveys. When primary estimates proved inadequate, OTIS staff sought supplementary information. Slippage between graduation from vocational school and job market entry was estimated through a combination of state and national data, for example. Employment security data on registrants "available for placement" with out-of-state addresses were used in an estimate of outmigration (strangely, there appeared to be no attempt to estimate in-migration).

OTIS staff offered a useful critique of their own model as its current state of development:

1. Not all jobs are included in projections. They expect this gap to cause an understatement of demand.
2. The system yields no information on education-experience complementarity. This, of course, is a failing common to most forecasting models, and is based mainly on the lack of systematic research into alternative routes to different occupational levels.
3. Some individuals listed as available from non-institutional sources (in-plant training and unemployment data from employment security records) are not in fact qualified for jobs in their listed category.
4. There are some inconsistencies between regional and state occupational totals. Some occupations could not be identified at the regional level.

In addition, we note several points of criticism applicable to OTIS and to systems models generally:

1. Information on non-institutional supply sources is particularly poor. Reliance on employment security records forces a serious underestimate of the numbers of individuals who gain skills through on-the-job experience.
2. OTIS covers the manufacturing sector quite comprehensively, but its treatment of services and government (the state's fastest growing sectors) leaves much to be desired. Whereas contacts with manufacturing industries are renewed annually, the services benchmark is old and subject to rapid obsolescence.
3. OTIS uses wage data to help explain inter-state migration, but inter-state wage differentials are not used to explain supply-demand adjustments in Oklahoma labor markets. (This criticism applies with more or less equal force to all technological forecasting models).
4. In this view, regional imbalances are presumed to be immutable during the forecast period. The assumption of zero intra-state mobility may be reasonable for a short period, but longer-range projections should allow

for the possibility that surplus regions contribute labor to shortage regions.

5. Teachers and students showed considerable disagreement when asked to judge the relevance of vocational education curriculum to job content. We have no standard to judge the "right" answer in this case.
6. Aside from the reporting-budgeting needs of any state agency, it is not wholly clear that a one-year cycle is desirable for all phases of system planning and forecasting. The short-term cycle may have to be integrated onto one or more long-term cycles covering programs with multi-year gestation periods.
7. The evaluation phase of OTIS is quite underdeveloped. Supporting wage data, though available as mentioned, is not used intelligently. Control for evaluation of vocational education programs based on data from dropouts may have serious unknown biases, depending on the array of factors which caused individuals to leave school.
8. The percent of expected demand which is to be filled from each supply source is based on the percent of supply currently emanating from that source. We have no way of knowing the extent to which employers prefer this pattern or how generally optimal the pattern is in an economic sense.

Nevertheless, the OTIS technique, perhaps the most comprehensive of the systems models discussed, remains a well-conceived method for assembling and organizing labor market information. It is understandable to administrators as well as to trained economists. And it involves interested groups and citizens from industry and education in the data gathering and forecasting process itself. If spin off from this interaction includes better understanding between industrialists and vocational education personnel, then the program will have had a positive impact regardless of the accuracy of its forecasts.

Systems Models with More Sophisticated Economic Assumptions

The NPA Forecast and a SMSA Variant

Forecasting models based on systems which elaborate production and demand assumptions and which grapple with the problem of an operational "shortage" definition reflect more sophisticated economic assumptions than do the systems models discussed above. Structurally, they do not represent complete, simultaneous-equation labor market models, but their attention to economic rigor sets them apart from previously discussed cases. We shall begin by considering the National Planning Association's projections of state and area economic trends, which are described in Al-Samarie and Scott (1970), Darmstadter (1966), Teeple (1970) and the NPA, *Economic and Demographic Projections* (1966). Projections of special interest to vocational education planners are found in NPA, *Vocational Technical Education in the 1970's* (1970), with working papers on health, social welfare, science and technology, construction and transportation.

As part of the National Planning Association program, the Center for Priority Analysis made state and regional projections of income and employment

for the period 1966-1975. The model on which these projections were based is built around a series of estimating equations. Operation of the model depends on a supply of labor function (exactly comparable in its initial stages to the Inter-Agency Growth Project procedure.) Al-Samarrie and Scott describe the production function in this model as linear and homogeneous, of the Cobb-Douglas variety, that is:

$$\text{Output} = \text{Capital}^{a} \times \text{Labor}^{1-a} : \text{no increasing or decreasing returns to scale}$$

In specifying a production function of this type, the NPA implicity transcends the "fixed coefficients" assumptions of the BLS model.

The production function generates capital needs, which in turn yields predicted plant and equipment expenditures. Consumption expenditure is derived from a standard consumption function. Government expenditure is analyzed by functional parts. The final expenditures total is then broken down by industry and further converted to two-digit census occupational distributions. State projections take the form of industry employment totals and shares by state, and population-employment growth (classified by age and sex), after adjustment for migration. Projections appear in the form of three options:

1. Target, assumes full capacity output will be attained;
2. Present policy, assumes government leaves unchanged policies designed to foster growth;
3. Judgment, a probabilistic forecast, the title of which is self-explanatory.

By concentrating on area projections rather than working to achieve inter-industry completeness and consistency, as the BLS has done, the NPA may have sacrificed some of the internal discipline imposed by the input/output format. On the other hand, the data, geographically disaggregated, may be of more immediate use to vocational education planners whose focus will typically be sub-national.

The University of Colorado's Denver project (Fishman, 1966) coupled well-defined production functions with industry-occupational matrixes to project employment by occupation. They chose this technique from a list of potential methods, including naive-no change, naive-national trends, projection of SMSA trends, a variant of the community base study and analysis of the components of change in employment patterns, (change in the relationship between national and local employment patterns means either a change in local share of an industry or shift in factor proportions).

Forecast Models for Specific Occupations

The Arizona State (1967) study of needs for aviation personnel, and Heady and Arcus' (1966) study of vocational education needs in agriculture provide excellent examples of occupational forecasts based on sound econometric analysis of market forces.

The Arizona study reports painstaking tests of models to explain employment of pilots and mechanics in aviation, together with a detailed discussion of supply sources and trends. Assumptions, which relate to GNP growth, percent allocation of GNP to transportation, percent allocation within transportation

sector to air transportation, international conditions and productivity are well thought out and realistic.

Heady and Arcus report work on a sizable project involving:

1. Developing an input/output matrix for agriculture;
2. Building a mathematical programming model (sectored regionally) for the industry;
3. Applying regression analysis to establish manpower requirements;
4. Undertaking a rural/urban migration study;
5. Testing production functions in which labor is divided into vocational education categories.

In a sense, this model belongs in the "economic" category discussed below, since one part of the analysis involves maximizing production, subject to certain input constraints. It is too early to tell, however, how the model, or any part of it, will be used in the forecasting process.

Labor Market Studies and the "Shortage" Problem

Labor market studies, designed to yield economic analysis of the interaction between behavioral and institutional forces in occupational and geographical labor markets, have honed and refined the concept of "shortage" in ways that may prove useful to planners. Theoretical models, such as that developed by Arrow and Capron (1969), are supplemented by theoretical and empirical work of Freeman (1971), Devine (1970), Yett (1966), Franke and Sobel (1970) and Folk (1970).

Two common definitions of shortage are associated with work by Blank and Stigler (1957) and Arrow and Capron (1969). The former authors relate shortages to rising relative wages, asserting that shortage results when employers cannot secure "adequate" labor at a recently-prevailing wage rate. (At each reference point, however, the market clears at a higher wage). Arrow and Capron depict a "dynamic" shortage, wherein requirements exceed availables because ever-rising demand (for scientists and engineers) consistently outdistances supply. Relative wages rise in this model as well, but not at a rate fast enough to clear the market at new equilibrium levels.

Devine criticizes Blank and Stigler on empirical grounds (shortages may or may not be accompanied by rising relative wages) and Arrow and Capron on theoretical grounds (the authors maintain an unstated assumption of monopsony). He then proposes a theory of shortage based on monopsony in the labor market. (Note that monopsony implies the buyer of labor will, acting to maximize his own gain, restrict his purchases below the level that will prevail in a free market). Yett's model of nursing salary differentials also employs an assumption of monopsony, but uses an Arrow-Capron dynamic shortage approach as well.

Freeman's *The Market for College Trained Manpower* uses a cobweb model that generates dynamic shortages and surpluses due, not to lagged salary responses to demand (Arrow and Capron) but to lagged salary responses to supply. This approach should seem reasonable to vocational education planners, who are conscious of long gestation periods in the educational supply process. (Supply responses may be accelerated of course, by employer on-the-job training programs).

Franke and Sobel, and Folk, in studies of markets for highly-skilled personnel, adopt differing positions on the value of shortage concepts. In a skeptical vein, Folk after discussing a variety of possible shortage definitions, argues that "shortage" should be thought of as the consequence of excess demand, measurable in terms of changes in wage rates, vacancy rates, turnover rates and utilization patterns. Franke and Sobel, on the other hand, adopt a modified version of the Blank-Stigler definition and proceed to enter quantities of supporting measures, including wage data, to analyze the nature of skilled worker shortages.

Theoretical and empirical work on operational definitions of shortage have followed different paths, as we can readily see. The forecaster should be aware of the assumptions under which "shortage" may be used to measure labor market conditions. The studies cited usefully point up the economic restrictions involved. In summary, this section has discussed "specified" (in a structural sense) technological models. Most vocational education planners make use of technological forecasting models, the projections of which rest on specified assumptions about change in economic activity, employment and productivity. Most systems models separate "demand" and "supply" projections but these relations depend less on relating behavior to wage rates than on intelligent projection of past trends in the labor force and employment.

Data inputs for these projections may include local adaptation of national figures (such as the Bureau of Labor Statistics' industry-occupational matrix or the National Planning Association's area projection model), as well as primary data from the planning area. Systems analysis generally serves to focus and organize the data-gathering process, though financial and time constraints may force the planner to consider using a variant such as the community economic base approach.

None of the models considered really make significant use of wage information, though such data are normally collected as a matter of course (e.g., Arnold's study and OTIS). And none fully consider the full range of labor supply sources, including schools, in-plant training, the military, and informal on-the-job learning.

Models, the basic dynamics of which lead to forecasting of occupational or educational magnitudes, generally fall in the "technological" category because production relationships are assumed to be fixed or smoothly changing throughout the forecast period. "Economic" and "predictive" models, as we shall see, may be coupled with technological forecasting assumptions at certain points, but their purpose, that of specifying optimum solutions to a problem, lends them a slightly different flavor.

"SPECIFIED ECONOMIC" MODELS

Programming

We shall discuss two types of optimizing processes, programming and cost-benefit analysis, and consider their implications for manpower forecasting.

Models developed by McNamara (1970, 1971) and Maki 1967, 1970) illustrate a combination of forecasting and programming. Standard references to the use of programming in manpower and educational planning include Davis (1966) and Bowles (1969).

Linear (and non-linear) programming describes a process of optimizing (maximizing, minimizing) some definable social objective subject to one or more "constraints." In economic terms, if production (welfare) is maximized, subject to the constraints of limited resources, the resulting allocation should be "efficient." McNamara's program objective, for example, is to secure the efficient allocation of a fixed vocational education budget in order to eliminate manpower shortages. He divides his analysis into two parts. First, a manpower forecast by educational level must be secured. Equations which produce this information are not complex; graduates are either projected by trend or by some fixed parameter which adjusts for dropping out. Non-institutional supply sources constitute a residual category, over which policy-makers have no control. Demand is allocated over a three-year period. The supply-demand "posture" (essentially the same as the OTIS "net demand") is then computable for each of the three forecast years.

Planners have the option of altering the forecast, however, by manipulating an instrument variable, in this case funds for additional vocational education graduates that might be attracted to particular programs.

Phase two of the process involves securing the optimum number of additional graduates, by program, subject to:

1. Labor market constraints: additional graduates, by program, cannot exceed observed market shortages;
2. Program constraints: (capacity constraints) additional graduates cannot exceed or fall short of certain stipulated program maximum or minimum levels; availability of funds enters as a capacity constraint.

The solution allocates additional students among the available occupational education programs. It should be noted that forecasting, in McNamara's model, is a means rather than an end. The principal focus is the internal workings of an educational system, rather than the operation of a labor market. For this reason, the economic assumptions behind McNamara's elaborate scheme are as primitive as those that underlie many technological models.

Maki's program approaches shortage reduction in a different fashion. Again, the author uses a two step procedure, beginning with industry/occupation pro-

jections (not educational projections, in this instance). Maki then introduces a definition of "desired" occupational structure:

a = Employment + Vacancies/Industrial Output

X = a(t) x Output (variables defined by industry/occupational category)

(X here represents "Demand" based on the relation of "desired" occupational structure, which may change over time, to the level of output).

The objective of his program is to minimize weighted relative shortage in an occupational category. Shortage is defined as "demand" minus employment, as a percent of "demand", weighted by the occupational wage rate. If wages, by assumption, reflect a worker's marginal contribution to production, then minimizing shortage implies that output (GNP) will be maximixed.

Constraints include the following:

1. Employment in an occupation cannot exceed the labor force;
2. Current employment cannot exceed the total of employment one period earlier plus supply of persons entering the labor force (the latter explained in a separate equation);
3. Total labor earnings cannot exceed an independently computed labor share of GNP.

Maki makes no explicit provision for policy manipulation, but the implication of his optimizing model seems to be that employment (the only non-forecasted variable) must somehow be altered to achieve optimality.

These models make use of data bases described for earlier techniques, and the McNamara system may have a specific practical application in budget allocation. Their value in forecasting is limited, however, by the assumption that projected values will be altered during the forecasting period. Without a complementary behavioral model to test magnitude of supply-demand changes, it would be difficult to explain predicted minus actual discrepancies as resulting from deliberate policy efforts or from events beyond the policy-maker's control. The forecasting segments of these models are quite underdeveloped, as mentioned above. This fact may be of crucial significance to the value of programming solutions. If current industry-occupational patterns are not "efficient" or optimal, in an economic sense (and we have no special reason to believe that they are), then forecasts based on them will not produce efficient patterns. Thus, the "efficient" solutions to problems raised in the two models we have discussed would be partial, at best, and erroneous, at the worst.

Cost-Benefit Studies

Cost-effectiveness, or cost-benefit analysis, makes use of optimizing assumptions (which program or allocation of expenditure will produce the greatest net benefit), but requires no direct computation of existence of or change in shortage magnitudes. Generally speaking an analyst bases cost-effectiveness judgements on the following relation:

Net benefits = Extra benefits from undertaking plan A
- (plan A) —Extra costs required for plan A

Since costs and benefits of most programs accrue over a time period greater than one year, it is customary to calculate the present values of these data. Hypothetically, a policy-maker, with or without the constraint of a given program budget can choose the most efficient (greatest net benefit) from among an array of projects.

In a manpower context, discounted earnings streams of different occupational groups should rise and fall according to changed market conditions. These "benefit" streams, combined with appropriate data on alternative costs of supplying needed labor, should produce an "efficient" solution to specific market imbalance problems. Such data can moreover, provide a technical evaluation of the effectiveness of an existing program. An alternative evaluative technique for vocational education planning is described in Schure (1971).

Unfortunately, since cost-benefit calculations rest on *post hoc* data, they are subject to the same criticisms levied against other forecast-policy tools. Unless the researcher has a way accurately to predict changes in profiles or changes in cost relationships, forecasts based on cost-effectiveness studies will reflect mechanistic, technological assumptions. Cost-effectiveness studies do, however, provide forecasters with useful reminders that resource allocation may be affected by changing resource values, a process not normally accounted for in projective models.

Somers and Wood (1969) present useful studies of cost-benefit techniques applied in the manpower area. An article by Wilkinson (1966) illustrates techniques and pitfalls encountered in computing occupational lifetime earnings. Corazzini (1966) and Kraft (1969) apply cost-benefit measures specifically in the vocational education area. Gaddis (1970), and Little and Whinfield (1970) present progress reports on vocational education follow-up studies designed to produce evaluative data.

Optimizing models used in manpower forecasting remain primitive in design and of limited usefulness for vocational education planners. They generally fail to incorporate the scope and detail of systems or input/output models, and they lack the theoretical elegance and rigor of prediction models, consideration of which will round out our review of forecasting techniques.

"SPECIFIED PREDICTIVE" MODELS

Econometric models of sufficient comprehensiveness to permit cautions prediction and simulation are rare in the labor/manpower field. An "ideal" model for such an effort can be found in Bowman (1969) who reports on a model developed by Malinvaud. Manpower requirements models which integrate educational and manpower planning have been built and tested with European data (see Correa, "Survey of Mathematical Models" in Organization for Economic Cooperation and Development, 1967, and Correa, 1969). Tella and Tinsley (1967) have reported on the labor sector of the FRB-MIT econometric model for the U.S. Based on sophisticated neo-classical production assumptions, this subsystem, in the context of the total model, should permit simulation of market solutions under alternative assumptions.

Estimating demand and supply equations from empirical data is a hazardous procedure, given the current state of the art. One must identify, from crude data on employment and wages, to what extent observed changes reflect changed demand, changed supply or some combination of the two. Hence, a "demand curve" fitted to a set of points and used for forecasting purposes may be no demand curve at all, but rather some mongrel equation which combines supply and demand changes.

Adequate models of this kind, however logically tight, require considerable professional expertise and computer time to specify and test. For optimum results, historical series of great variety are necessary, and for many important variables (e.g., wages) the data may simply not exist. Burford's (1966) use of cross-section and time series data in a multi-equation model applied in Georgia illustrates one alternative, but one which should be approached with care. (See Johnston, 1963.)

It is not clear, moreover, that predictive models, given the current state of the art, will produce greater accuracy than alternative approaches. Niedercorn (1967) reports that his test of a multi-equation model against forecasts of a naive model showed the former to be superior but, in his judgment, not conclusively superior.

Output from most econometric projections must still be combined with matrixes that relate product to occupation and/or education, in order to secure data valuable to the vocational education planner. Until we can introduce vocational education categories directly into production equations and specify, and identify, demand equations for occupational/educational categories, we shall have to be content with subjective assumptions about the fixity or lack of it in a given occupation/education structure.

To summarize, this discussion has ranged over forecasting models differentiated by explicitness of structure and assumptions and by assumptions concerning the importance of wages, costs and prices for economic behavior. Though specified economic and predictive models probably best reflect the stringent requirements most economists would place on "good" models, the average vocational education will find them costly to prepare (considering the expense of professional consultants) and difficult to understand. At present, moreover, there is no evidence that these sophisticated techniques produce more accurate results than do simpler technological models.

Specified technological models are preferable to unspecified models, since no one can usefully evaluate the predictions of a technique the assumptions of which are unclear. Which technological model a vocational planner should use depends on the volume and quality of local data available, the time and resources available, and the kind of forecast needed. Consistency is best achieved with forecasts based on input/output analysis. As mentioned, this approach is time-consuming and may require considerable time from professional economists. Systems approaches organize labor market data well. Full consistency is less likely, in an inter-industry sense. Data costs will probably match those associated with input/output models. But systems models are generally more comprehensible to the vocational education planner and other potential users. Less absorption with technique, moreover, seems to allow greater energy to be expended in opening communications between producers and users of trained personnel, as in the OTIS system.

Under some circumstances, vocational planners may conclude that precise quantitative projections are not required. Technology studies, expert surveys and Medvin unfilled-openings studies may fill some planners' needs. It should be remembered, however, that forecasts based on these techniques will be difficult to evaluate, particularly if underlying assumptions are not specified. This author feels that such qualitative material serves best to complement quantitative forecasts based on a specified technological model.

DATA AVAILABILITY AND QUALITY

Data quality vitally affects the usefulness of a forecast by whatever technique achieved. Therefore, we shall discuss selected problems in the collection and classification of data inputs for manpower forecasts.

Because unspecified models rely heavily on a special data base, we discussed the validity of surveys in an earlier section. A number of biases created by misunderstanding of questions could be removed by substituting personal interviews for the widely-used mail questionnaire. Researchers must weigh the value of increased precision of measurement against a probable loss in degrees of freedom from reduced sample size. Greater attention should be given to *ad hoc* studies of employer forecasting models, whether explicit or implicit, and the forces which cause employers to alter the way they project needs.

In the remainder of this section, we shall concentrate on four problems:

1. The validity of commonly-used occupational classifications;
2. Information on inter-occupational substitutability (demand) and mobility (supply);
3. Biases and comparability in national data;
4. Problems of occupation/education matching.

Occupational Classifications

An ideal typology of occupations, from a manpower planner's point of view, would isolate jobs of homogeneous "skill" content for which the education/training/experience requirements are reasonably specific and understood. In economic terms, the substitution elasticity within the occupational category should be infinite, but substitution among categories should be some known value less than infinity. Titles used should describe the job content, and should be agreed on by all potential users. Classification should embrace, with equal specificity, all jobs within the system.

In practice, of course, every job is unique, representing the resultant interaction of employers' ideal expectations and the actual capabilities of the job's temporary occupant. But shortcomings of our current classification schemes run much deeper, as recent analysis has shown.

Current detailed occupational information derives from the decennial census and, in less detail, the monthly reports on the labor force issued by the Census Bureau. The Department of Labor also publishes a *Guide to Local Occupational Information* (1969), which covers data from *ad hoc* area skill surveys.

Scoville (1965, 1969) has criticized census classification and coverage of occupations in several articles (see also Shea, 1969). Though agreeing that census household surveys may produce more accurate information than employer sur-

veys, he notes an average difference between household interviews and employer follow-up surveys to obtain occupational data about one-sixth. Scoville argues from history that census classifications reflect concern with social class or position, rather than skill or functional content of a job. Weitzman (in Pinsky, 1969) notes that 1970 census occupational questions included supplementary job description information, as well as a question on the respondent's vocational education background. Titles used remain the same as those used in previous censuses, however.

Coverage constitutes another source of difficulty with the census system. Shea notes that one-third of all jobs fall in the "not elsewhere classified" category, and Scoville adds that changes in the proportion of a one-digit group falling into the "n.e.c." slot are uneven over time and across occupations. According to his figures, whereas total "professional, technical and kindred" employment grew by 47 percent from 1950-60, "professional, technical and kindred, "n.e.c." grew by 256.5 percent.

Staff members of the President's Committee to Appraise Employment and Unemployment Statistics (1962), the Gordon Committee, felt that the reliability of occupational data from the Bureau of Labor Statistics, *Monthly Report on the Labor Force* exceeded the reliability of decennial census data, because better-trained interviewers conducted the former surveys. Discrepancies between the two exist, but are uneven by occupation.

The Gordon Committee notes other possible sources of occupational information:

1. Data published by licensing or professional societies;
2. Special federal employer surveys for certain occupations, such as engineers and scientists;
3. Occupational information from reports of regulated industries;
4. Occupational information from Bureau of Labor Statistics' wage rate studies.

These sources vary in periodicity of collection and in comparability with other published data.

An alternative classification scheme, developed by the Department of Labor, has been applied in many local studies. The *Dictionary of Occupational Titles* (1965), in two volumes, publishes job descriptions and "ratings" at the six-digit level. A job is classified according to its general "job family," according to general educational requirements (GED), according to specific vocational preparation requirements (SVP) and according to a three-digit scheme which rates the job's relation to "data," "people," and "things." (See *DOT* Supplement, 1966.) Further detail may be obtained by attaching suffix codes to *DOT* job codes, as described in U.S. Department of Labor, *Suffix Codes for Jobs Defined in the Dictionary of Occupational Titles* (1967). Scoville notes that use of the data-people-things system brings us no closer to a skill-defined classification scheme. GED-SVP requirements are set by panels of experts. Unfortunately, our knowledge of how, in fact, one enters an occupation leaves much to be desired. Horowitz and Herrnstadt (1967), for example, note that entry into the tool and die trades occurs by way of multiple paths, with varying combinations of education, training and experience over differing time periods. Richard Eckaus' (1964)

study of the educational structure of U.S. jobs, which uses GED-SVP breakdowns, reveals a wide range of attainment for almost all categories tested. Though more educationally specific than the census classification, the *DOT* system should develop more accurate breakdowns of skill levels of jobs.

Perkins *et al.* (1968) tried to define tasks associated with certain office jobs, using *DOT* classifications. They found that size and industry classifications affected the nature of tasks performed by individuals with a common job title. *DOT* job classifications may include industrial process stratifications, but do not correct for size. Battelle's (1970) study of skill content in selected occupations with curricular implications for vocational education, represents another attempt to isolate the functional content of jobs.

Research to identify "job clusters," families of occupations which share common preparational requirements, has multiplied in recent years. A thorough analysis of the job cluster concept may be found in Cunningham (1969). See also Quirk and Sheehan (1960) and March (1966). An interesting variant, in Cole and Whitney (1971), involves grouping occupations by subjective characteristics of the job-holders, a reflection of increased interest in the "requirements-availables" interaction in job definition found in Scoville's theoretical model and in a discussion by Staley (1967), who would classify jobs by "skill," "knowledge," "personality traits."

If occupational data collected by the census are to be used in the more comprehensive *DOT* classification scheme, a reconciliation should be attempted. Work undertaken by the Inter-Agency Occupational Classification Committee (Census Bureau and U.S. Training and Employment Service) should produce results of interest to all occupational planners. Analysis of the preliminary data from this venture proceeds under the direction of Ann Miller (1970) at the University of Pennsylvania.

Inter-Occupational Substitutability and Mobility

Accurate occupational forecasts require some assumption concerning the movement of individuals among occupations. Conceptually, this process involves employer and/or worker choice.

An employer, faced with persistent external vacancies in a critical occupation, might be expected to alter the production process or develop internal sources of supply. Capital-intensive techniques may remove the need for scarce personnel. Or internal promotion and upgrading programs may permit the employer to cease dependence on external supply. A good discussion of conditions surrounding such decisions may be found in Doeringer and Piore (1971) and in U.S. Department of Labor, *Work Force Adjustments* (1968).

To this author's knowledge, no attempts have been made to test the effects on employer demands for different occupational categories of changes in economic and non-economic variables. Bowles (1969) has shown that the elasticity of substitution among educational categories is quite high, meaning that the employer has considerable incentive to change the educational mix of his work force in response to changes in the prices of different educational categories.

Hollister, (in Sinha, 1965), speculates that the elasticity of substitution within high-skill occupations is lower than within low skill occupations, a point Stromsdofer (1969) supports with evidence for occupational job change by skill level. His data, however, reflect the joint determination of job patterns by employers and workers. If further work indicates that highly-skilled personnel do move among occupations less readily than do less skilled personnel, the task of the vocational education/manpower forecaster will be simplified. Further information on employer response in the form of internal manpower development is necessary also. Swerdloff's (1970) attempt to study the feasibility of regular employer training reporting to the Department of Labor represents a step in this direction.

Work on occupational mobility is reported in Blau and Duncan (1967), Stein and Johnson (1968) and Saben (1966). Again, little has been done to explain occupational mobility. Saben's measures cover but one year, and further study is necessary to determine how useful such a time period is for charting workers moves.

National Data

The Gordon Committee's report (President's Committee. . .1962) on unemployment and employment statistics remains the best recent analysis of strengths and weaknesses in national data. (See also selected presentations from the National Conference on Program Planning and Evaluation, 1969, for discussion of the *Standard Industrial Classification,* the *Dictionary of Occupational Titles* and *Vocational Education and Occupations.)* The Gordon Committee, which makes use of the expertise of consulting economists and the self-evaluation of government agencies, compares employment series generated by the Census Bureau—Current Population Survey, (see also *Subject Reports: Occupation by Industry, 1963),* the Bureau of Labor Statistics Employment and Earnings series and the Bureau of Employment Security data based on unemployment insurance reports—Area Labor Market Trends. (For early BES labor market studies, see Area Redevelopment Manpower Reports.) The following discussion draws heavily on the Committee's analysis.

Employment security data, based on unemployment insurance employer filings and registered unemployment, is available, weekly, but with obviously limited coverage. Data appear in raw form, moreover, and the Census Bureau makes no attempt to adjust for seasonal fluctuations. Because the Bureau has no direct power over state collection practices, there is a certain amount of incomparability among states' data. As with the area skill survey, the Bureau can but suggest a uniform technique (see, for example, BES, *Handbook on Development of Basic Labor Market Information for Small Areas, 1960).* "Shortage" estimates for labor market areas have limited analytical significance, since they are defined by reference to unemployment rates alone.

Given the obvious limitations of employment security figures, users of national data have tended to rely on census and BLS employment totals. In response to the Gordon Committee's recommendations, employment data, formerly collected separately by the BLS and Census Bureau, now appear monthly.

in the Bureau of Labor Statistics *Employment and Earnings and Monthly Report on the Labor Force*. The Census Bureau still collects labor force data for the BLS, but employment data from census household surveys appear separate from BLS data, gathered directly from employers. Comparison of these systems can best be made point by point:

1. Collection units: BLS units are firms; census units are households;
2. Method: BLS uses mail questionaire to non-random sample (bias, therefore unknown); census data are collected by personal interview of carefully-chosen random sample;
3. Respondent age: no cutoff for BLS; 16 years and older for census;
4. Collection period: about one week for both;
5. Treatment of self-employed: evidence that census listed some salaried persons as self-employed (confusion or wishful thinking);
6. Criticisms: BLS
    a. No error estimates, non-random sample (for example, 100 percent coverage in federal government, 1 percent in religious and charitable organizations);
    b. Poor small firm coverage;
    c. Poor standards for service industries;
    d. Dual job holders counted twice;
7. Criticisms: Census
    a. Errors of memory failure, lack of records, falsification by respondents;
    b. Census undercount, especially in certain big city neighborhoods.

The Census Bureau builds into its procedures special studies to check accuracy, particularly of decennial data. (See U.S. Department of Commerce, Bureau of the Census *Evaluation and Research Program*. . .series ER60) On this point, the Gordon Committee generally felt that BLS procedures needed to be improved in the area of evaluation and statistical sampling validation.

A new source of national employment data (by one-digit occupational category) available in published form for 1966 and 1969, is the Equal Employment Opportunity Report issued by the U.S. Equal Employment Opportunity Commission. These figures show occupational distributions in major industries, for the nation, states and some SMSA's, by sex and by race—a feature unique to this source. Though all firms with 25 or more employees must report, coverage has been uneven by industry, with a probable overall increase in reporting percentage as time passes.

The census household survey procedure emerges with higher marks for statistical accuracy than does the BLS employer survey procedure, but the latter may have use for some kinds of analysis, particularly where annual employment data by state and industry are wanted in a convenient historical series.

We should mention, at this point, the drive to build series on job vacancies, a development which is of considerable interest to manpower forecasters. The use of job vacancy and unemployment data to measure relative tightness in labor markets has long been discussed by scholars and administrators. The National Bureau of Economic Research (1966) provides an assessment of the potential

usefulness of such data, an interesting conceptual model of vacancies in a labor market system, and reports on vacancy studies undertaken by the National Industrial Conference Board and the BLS. For a simple practical vacancy model, see also Konstant and Wingeard (1968). Myron Joseph (1965) views such efforts with some skepticism. He notes that vacancies do not constitute "labor demand," that they have a time dimension (is a "vacancy rate" meaningful when the processing and recruitment time for different jobs may vary by months?), that some vacancies simply reflect the employer's desire to secure a better man for the job. Clearly further theoretical work is needed to refine the vacancy concept. Evaluative studies of vacancy series now collected by the BLS will be needed as well.

Occupation / Education Matching

Working from the *Dictionary of Occupational Titles* and from the *Standard Terminology* handbook (1967), the Departments of Labor and of Health, Education and Welfare developed, in 1969, a volume entitled *Vocational Education and Occupations*, an attempt to interface occupational classifications with vocational education curriculum classifications. Project VISION staff members contributed a section entitled "Occupational Cluster Reference Guide", in which *DOT* classifications were grouped and reworked to achieve greater homogeneity, with the results again matched to vocational education curricula. VISION staff also show a model conversion of the combined Departments of Labor and Health, Education and Welfare results to local vocational education course structures, using their own system as an example. Researchers interested in a reference for vocational education statistics available at the federal level should consult U.S. Department of Health, Education and Welfare, Adult and Vocational Education Branch (1970).

Though much valuable classificatory work has been done in occupational/educational matching, troublesome theoretical problems remain. Layard and Saigal (1966) test explanations of occupational and educational structure of the labor force, using OECD data. (See also a similar analysis by OECD staff, 1971.) They test the relationship:

$$\log L_i/L = a + b \log X/L$$

$$\log L_j/L = a + b \log X/L$$

where L_i/L represents occupation i's proportion of the labor force;

L_j/L represents education level j's proportion of the labor force;

X/L represents productivity.

It is reasonable to ask why any particular occupational configuration should be associated with high or low productivity especially given the imprecision of occupational categories. Economic theory provides no justification for such a relation. Nonetheless, Layard and Saigal found in their test that L_i/L correlated better with productivity than did L_j/L, a fact which indirectly reinforces our earlier comments on the breadth of educational distributions within occupational categories. Were education level and occupational category rigidly linked, we should have expected to see a like correlation of both these variables with productivity.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

We have analyzed features of selected manpower forecasting methods, used under a variety of conditions and at various levels of aggregation. Let us now summarize this discussion by measuring forecasting models against criteria established in the first section of this paper.

I. General requirements of a manpower forecasting technique:

A. Most "specified" models stated general assumptions clearly. Assessment of reasonableness of assumptions requires a value judgment by the user. Few models in the "non-economic" category clearly stated economic assumptions involved (such as fixed production techniques).

B. Replicability depends partly of course, on the size of the job to be done. None of the models discussed clearly indicated costs of data collection and analysis. OTIS "equated" figures on a per respondent basis, but failed to itemize the estimates' components. Only the econometric models would seem to require considerable technical expertise to test and operate. OTIS' recycling characteristic appears useful in that replication is built into the system.

C. Models based on flow charts and mathematical symbols may require a certain amount of time to digest, but should be clearer, once grasped, than less-precise verbal presentations. The forecasting segment of linear programming models proved to differ little from verbal and flow chart models developed for systems-based projections, and the former had the advantage of clarity and brevity.

D. No models included estimated forecast errors, a failing common to most projections.

E. Internal consistency of model projections can best be checked when the forecast is based on an inter-industry framework. Consistency tests can be appled to any model, however.

II. Requirements of a manpower forecasting model for planning vocational education:

A. Demand and supply forecasts are separated conceptually in the systems models and "economic" models. Some of the technological projections dealt only with "requirements," though presumably supply components could be included.

B. Morsch (OERA), OTIS and the Arnold study generated data detailed enough for vocational education planners. Other projections, of the input/output variety or based on econometric models, could produce occupation/education detail if the required conversion were made.

C. Technology assumptions tended to be most clearly spelled out in projections like the *Occupational Outlook Handbook*. There is no reason why similar care with technology forecasts should not be taken in other models, though specifying quantitative implications is exceedingly difficult. This author feels that alternative technology assumptions might be applied to produce interval rather than point estimates of future employment.

D. None of the models considered generate estimates of internal staff needs for the vocational education system.

E. None of the models tested adequately handle the supply side of the labor market equation. "Non-institutional" supply sources receive treatment as a residual, since most forecasters find securing information on institutional sources less troublesome.

F. Only the OTIS model explicitly incorporates, as a subsystem, programs to aid the disadvantaged. Reinhart (1971) notes the generally poor data availability in this area. The OTIS approach may improve the fairly unstructured inter-agency planning called for in the Cooperative Area Manpower Planning System (CAMPS), (See U.S. Department of Labor, *Manpower Report of the President,* 1971, p. 184.)4

III. Sensitivity to the interactions of labor market processes, the environment and the forecasting process itself: Only OTIS explicitly includes this important aspect of the planning process. By using industry coordinators and a broadly-based advisory committee, OTIS staff can expect increased (and hopefully improved) communication among forecasters, the vocational education establishment and users of the vocational education product. Area skill surveys, and some applications of the Medvin approach, incorporate inter-personal contact and exchange of information, but on an unsystematic basis.

Further Comments

Weakness in supply data and projection technique seemed to this author the most serious gaps in all techniques surveyed. Mangum and Nemore (1966) assert that supply weaknesses cause no problems, because employers are flexible in their recruitment techniques. It remains true, however, that lack of detailed supply information can lead to serious misestimates in the amount of vocational education expansion or contraction required.

Data gaps have been complemented by slow and uncertain development of theoretical and empirical work on labor supply. Early projections, such as that of nurses by West (1950) and the U.S. labor force by a U.S. Senate Subcommittee (1965) rested on fairly simplistic assumptions. Recent work by Bowen and Finegan (1965) on labor force participation, by Tella (1965), Strand and Dernburg (1965) on cyclical forces affecting supply should improve the structural quality

4. An alternative, under development at Pennsylvania State University, studies the process of coordinating data collection in a metropolitan area through the use of a simulation model (in U.S. Department of Labor, *Manpower Research Projects,* 1970).

of labor supply models. Rosenthal (1966) presents a useful supply projection technique for a single occupation. Blumen *et al.* (1955) discuss inter-industry mobility in the context of a probability model.

A more serious reason for poorly-developed supply estimates appears to be, in this author's opinion, the demand orientation of many manpower forecasters. It is assumed necessary to fill the employer's "need" regardless of the relative costs or benefits attached to a social solution of the problem (more vocational education expenditure) versus a private solution (employer change in technology). This demand orientation persists in the face of obvious supply problems that have dominated public thinking in recent years: i.e., how to integrate groups of "disadvantaged" citizens into the work force, how to place so-called "unemployables" in productive and satisfying jobs. One senses that, by implicit assumption, suppliers of labor, not demanders, should be called on to adjust behavior. For example, while claiming that student welfare is the ultimate goal of any vocational education system, OTIS staff convey the impression that the only "efficient" solution involves a lock-step march through a totally-integrated system into slots designed to eliminate shortages.

Recommendations

No one model clearly boasts more advantages than any other. The potential user should weigh the (subjective and objective) costs and benefits of a particular choice of model. Concrete judgments would, at best, require knowledge of the accuracy and bias of a particular system, and the costs of an error (in terms of resource misallocation) reducible by the use of a given model, relative to the model's development and operating costs.

Point estimates (requirements projections by the BLS and local adaptations, for example) are concise and allow fairly routine tests of accuracy. Interval estimates (Medvin unfilled openings approach) are less precise and more difficult to evaluate. But the vocational planner would do well to supplement quantitative forecasts with qualitative interval forecasts, whenever possible, in order that expert knowledge of local trends may supplement the output of mechanical projection models.

This author wishes to state a preference for the OTIS approach which, for forecasting at the state level, has definite advantages as a total systems concept. This model incorporates components which should make it possible to evaluate the system's total performance and its performance in solving specific problems, particularly those of the disadvantaged worker. Data are gathered and organized on a regular and systematic basis. Model design is easily comprehensible to all possible users.

OTIS principal "fault" is naivete of structure, from an economic point of view. Unfortunately, given the current inadequacies of more complex econometric models, it is clear that policy-makers must work with systems the structure of which may not wholly measure up to economists' standards. Other weaknesses of the OTIS model have been documented earlier in this paper. It should be noted that users could remove a number of gaps by undertaking appropriate *ad hoc* studies of labor market institutions and behavior in the forecast area.

Research Needs

1. Supply analysis must be strengthened through studies of paths to skill formation (comparable to the Horowitz-Herrnstadt focus) and occupational mobility.
2. Refinements of occupational theory, hopefully through occupationally-specific production functions, should assist empirical work described in Point 1.
3. Demand-side studies of employer choice of techniques, decisions to train and use various combinations of formal and informal education/training inputs are needed to complement supply studies.
4. Detailed analysis of industry (and vocational educational) experience with disadvantaged groups is necessary, in order that points of flexibility, on the supply or demand sides of the system, can be identified. Institutions and individuals may both have to adopt new responses and behavior patterns to solve this important social problem.
5. In a purely technical vein, more comparative analysis of the accuracy of alternative forecasting models must be done. To some extent, of course, these experiments depend on the willingness of public agencies to sponsor and fund research in forecasting. In the long run, such research should make possible some rationality in choosing a projection model, a result which could justify the initial expenditure. Tests should match models the structure and assumptions of which are clear and reasonable. Contrasting the performance of a test model against that of a naive model is a useful beginning, but the researcher should be prepared to submit two, plausible non-naive models to accuracy analysis in a controlled situation.

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